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How space science is forging ahead in the New Year

#200 JANUARY 2022

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

200 ISSUES OF ASTRONOMY

SPECIAL ISSUE

- ✦ Revisiting the great moments in space exploration
- ✦ Highlights from 15 years of observing the night sky
- ✦ Patrick Moore's advice for first time stargazers
- ✦ Meet the subscribers who've read every issue

A selection of our covers from 2005 to 2021. To see all 199, turn to page 26

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Welcome

Join our celebration of 200 issues of astronomy!

We're seeing in the New Year with extra cheer this month as it's our 200th issue, and we're taking the opportunity to reflect on all that has passed since our very first publication back in 2005. On **page 36**, you'll find Pete Lawrence and Paul Abel's recollections of the highlights to have graced the night skies over the past 16 years. Reviewing their observing records brought back the wonder and satisfaction of covering the Solar System and wider Galaxy on this long timescale (a mere blip by cosmic standards, of course) – and some rather amusing memories!

We've also been reporting on space exploration and science in the magazine since 2005, and there have certainly been some momentous developments since then. On **page 60**, Chris Lintott takes stock of them all and presents his pick of the most pivotal. His feature is a reminder of just how exciting it is to be covering the forefront of our quest for knowledge and discovery.

We've also included a word from our Editor Emeritus from 2005 to 2012, Patrick Moore. On **page 25** you'll find the column he wrote for issue 1 of the magazine – the first of more than 80. In it he imparts some sage advice for new stargazers, written in his own unique style, which is still as useful today as it ever was.

And we found out something remarkable putting this 200th issue together: that the number of readers who have subscribed since issue 1 stretches into triple figures. We meet just five of these 'stars of *Sky at Night Magazine*' on **page 30**, and find out more about their enduring interest in the night sky.

Clear skies, and a big thank you to all who've read us over the years!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 20 January 2022.

HOW TO CONTACT US

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

Online
Visit our website for competitions, astrophoto galleries, observing guides and more

Social media
Follow us on Twitter, Facebook and Instagram for space news, astro images and website updates

Podcasts
Listen to our Radio Astronomy podcasts where the magazine team and guests discuss astro news

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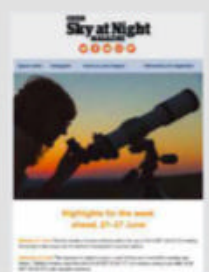

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16-PAGE CENTRE PULLOUT

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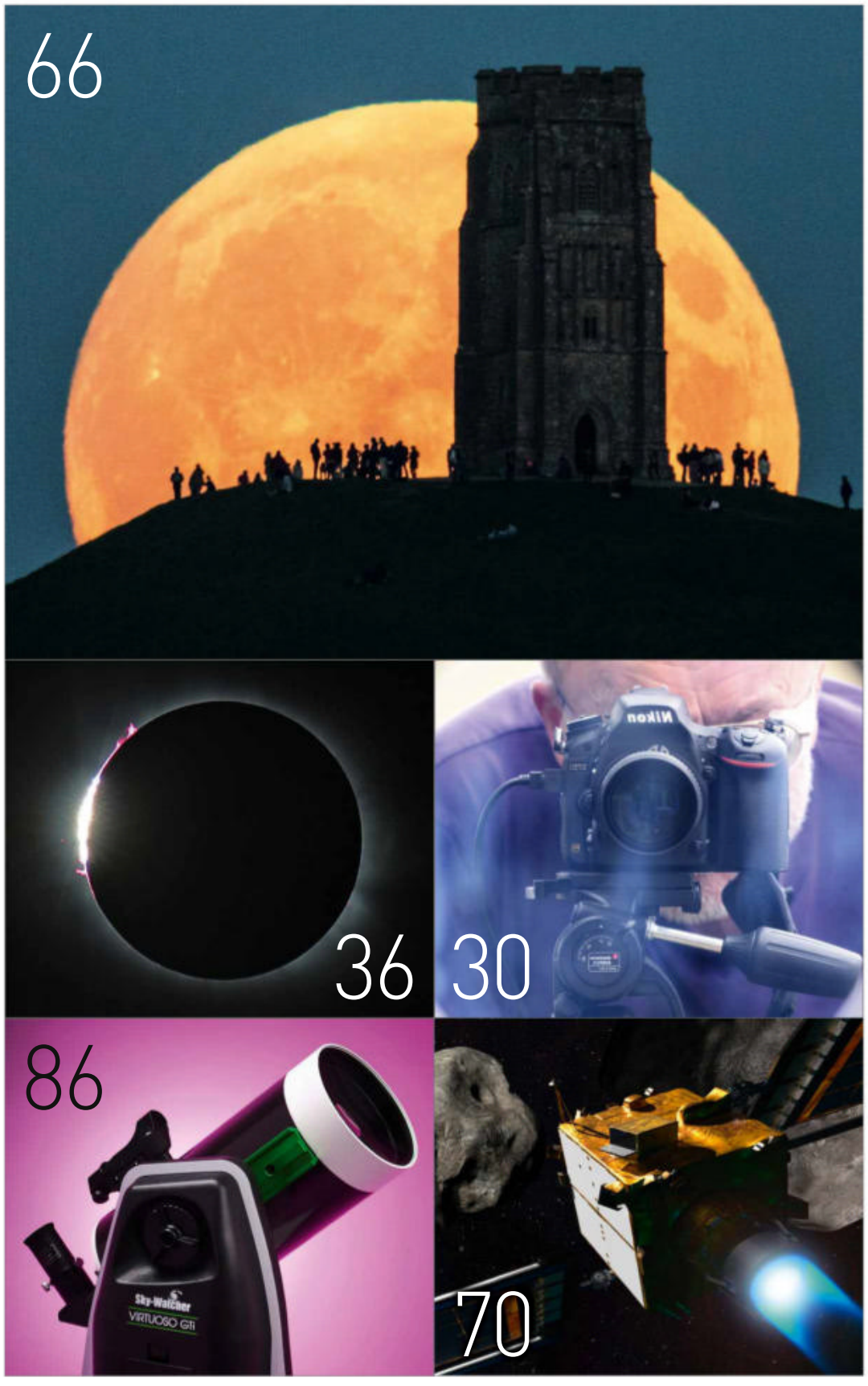
New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**



This month's contributors

Peter Leonard

Sky at Night **producer**

"*The Sky at Night* has always played an important role in my career, even before I started producing it!" **Peter compares his early experience on the programme in the 1990s to now,** **page 18**

Chris Lintott

Sky at Night **presenter**

"Having been there at the magazine's inception, it was wonderful to look back at all the progress over 16 years." **Chris selects his science highlights from 200 issues of the magazine,** **page 60**

Katrin Raynor-Evans

Astronomy writer

"Researching the sights of the night sky in the year ahead was a reminder of how wonderful our Universe is. We have so much to look forward to – I can't wait!" **Katrin prepares for stargazing in the New Year,** **page 66**

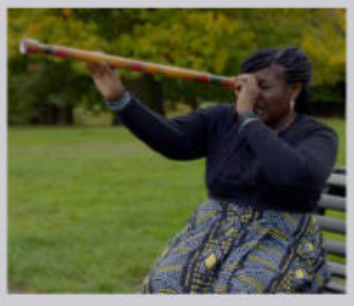
Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/D3LRQGM/** to access this month's selection of exclusive Bonus Content

JANUARY HIGHLIGHTS

200 issues of observing

Listen to Pete Lawrence and Paul Abel discuss their favourite astronomical events since issue 1 was launched.



Watch *The Sky at Night: Telecopes Through Time*

The team explore the history of the telescope, revealing the landmark instruments that have opened up the cosmos.

Book preview: *The Space Business*

Download and read an extract from a new book that takes a behind-the-scenes look at the private spacelight industry.

The Virtual Planetarium

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

MIND THE GAP

A spectacular new Hubble image reveals a mysterious hole in a nebula in the Large Magellanic Cloud

HUBBLE SPACE TELESCOPE, 2 NOVEMBER 2021

Why does this beautiful emission nebula have a gigantic hole in it? With a width of more than 250 lightyears, the dark 'superbubble' in N44, located 160,000 lightyears from Earth in the constellation of Dorado, is still puzzling astronomers.

The hole, glowing with the intense ultraviolet light from a region littered with hot young stars, seems likely to have been carved out by the outflow of superfast, broiling stellar winds from the massive blue-white stars at its centre. Measurements of wind velocities in the region, however, don't seem to bear this out. Another trigger may be a succession of central stars exploding in the last few million years, the resulting shockwaves blowing out the surrounding gas. Remnants of one supernova have been detected and strong X-ray emissions seem to confirm an explosive past. The discovery that stars inside and outside the superbubble are five million years apart in age only adds to the enigma.

MORE ONLINE
A gallery of these and more stunning space images

NASA/ESA/V. KOLL AND D. GOULIERMIS (UNIVERSITÄT HEIDELBERG); ET AL./ PROCESSING: GLADYS KOBER (NASA/CATHOLIC UNIVERSITY OF AMERICA)

△ Graveyard of galaxies

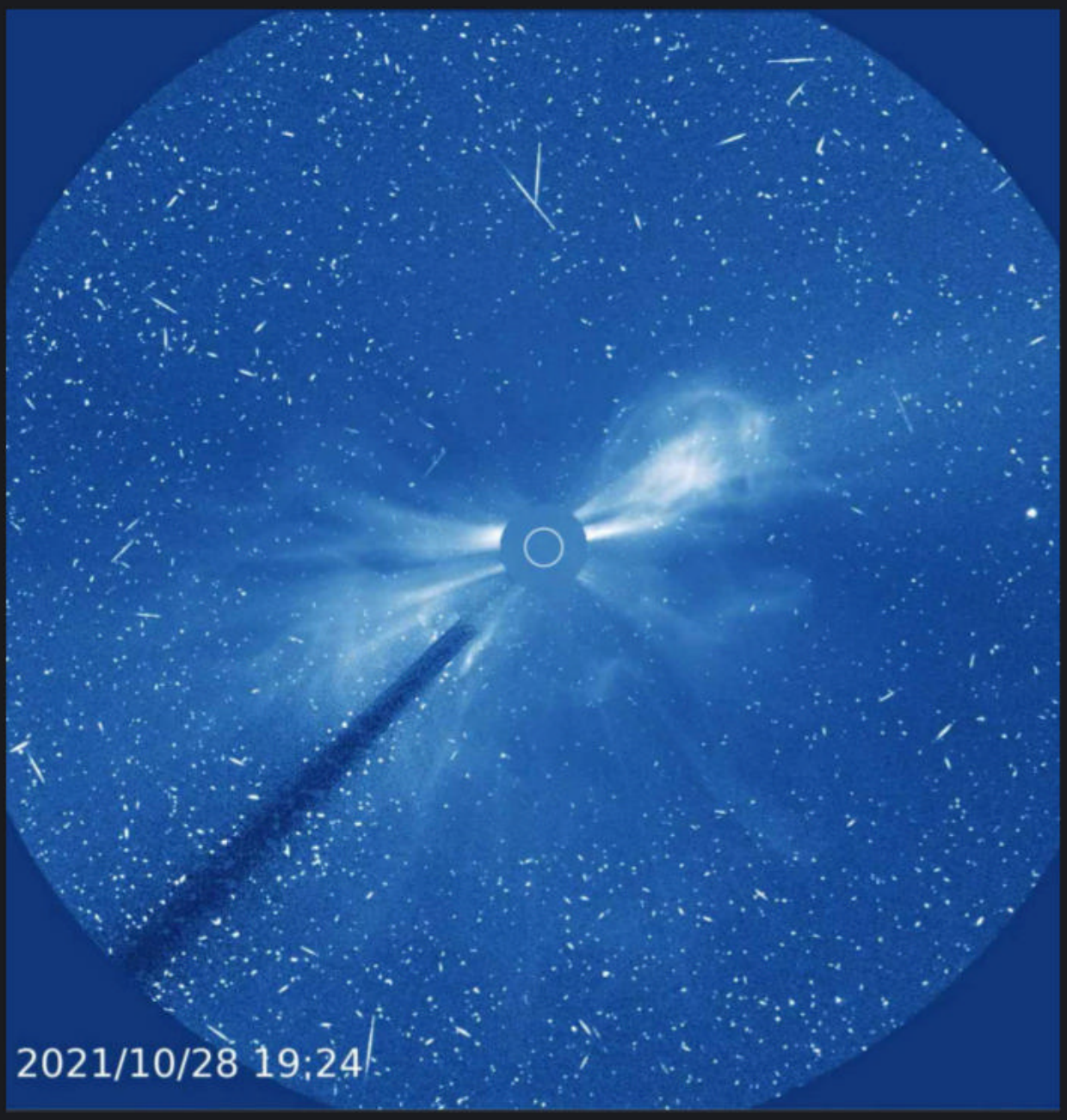
ALMA, 2 NOVEMBER 2021

Violent scuffles with the neighbours, hurtling at speeds of up to several million kilometres per hour and ploughing through million-degree plasma all contribute to the punishing, inhospitable environment that kills galaxies, new research has concluded. The VERTICO (Virgo Environment Traced in Carbon Monoxide Survey) study of 51 galaxies in the Virgo Cluster found that environmental factors in the Universe can be so spectacularly violent that entire galaxies can stop forming stars, creating a galaxy graveyard.

Here comes the Sun ▷

SOHO, 28 OCTOBER 2021

Solar activity is now kicking up a gear as we head towards the next solar maximum in the new cycle. Spectacular flares have been observed, including a massive X1-class flare that triggered a series of coronal mass ejections zooming towards Earth, sparking the most impressive aurora seen in years. To watch a sequence of eruptions, as captured over eight days by SOHO's coronagraph telescopes, visit **https://soho.nascom.nasa.gov/hotshots/2021_11_04**



ALMA (ESO/NAOJ/NRAO)/S. DAGNELLO (NRAO)/BÖHRINGER ET AL/(ROSAT ALL-SKY SURVEY), SOHO/LASCO (ESA/NASA/NRL/BRENDAN GALLAGHER), ESA/HUBBLE & NASA/A. SETH, NASA/ESA/A. SIMON (GODDARD SPACE FLIGHT CENTER) AND M.H. WONG (UNIVERSITY OF CALIFORNIA/BERKELEY) AND THE OPAL TEAM

△ Living on the edge

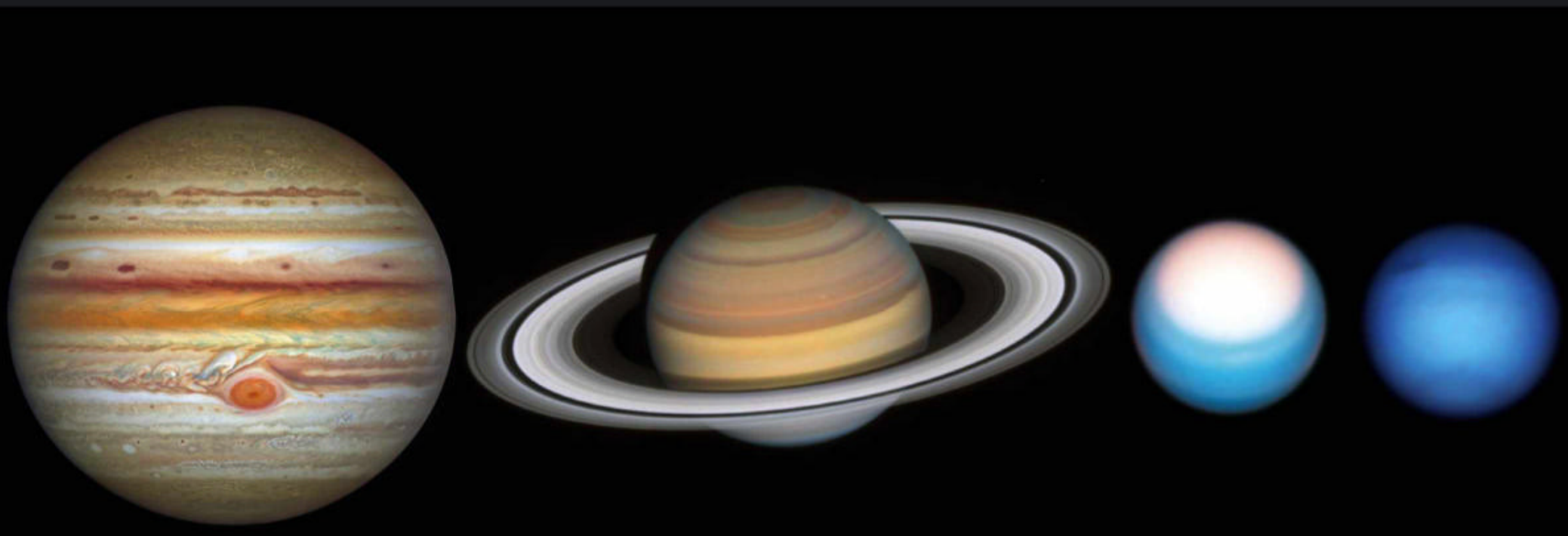
HUBBLE SPACE TELESCOPE, 15 NOVEMBER 2021

Handsome near-edge-on galaxy UGC 11537 may be 230 million lightyears away in Aquila, but Hubble's new infrared and visible wavelength image of it clearly shows tightly wound arms of dark dusty clouds and bright ribbons of stars. The two most prominent stars, however, don't belong to it: they are interlopers from our own galaxy that have crept into the foreground.

▽ Worlds apart

HUBBLE SPACE TELESCOPE, 18 NOVEMBER 2021

In this family portrait of the gaseous outer planets, Jupiter has several new dark red storm cyclone 'barges', while Saturn reveals the blue south pole of its southern hemisphere's winter. Uranus displays a bright northern pole, while its other half sits in a 21-year-long, dark winter, and on Neptune we still see the giant dark spot that surprised observers by dodging its demise earlier this year.



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BULLETIN

Juno reveals the depths of Jupiter's storms

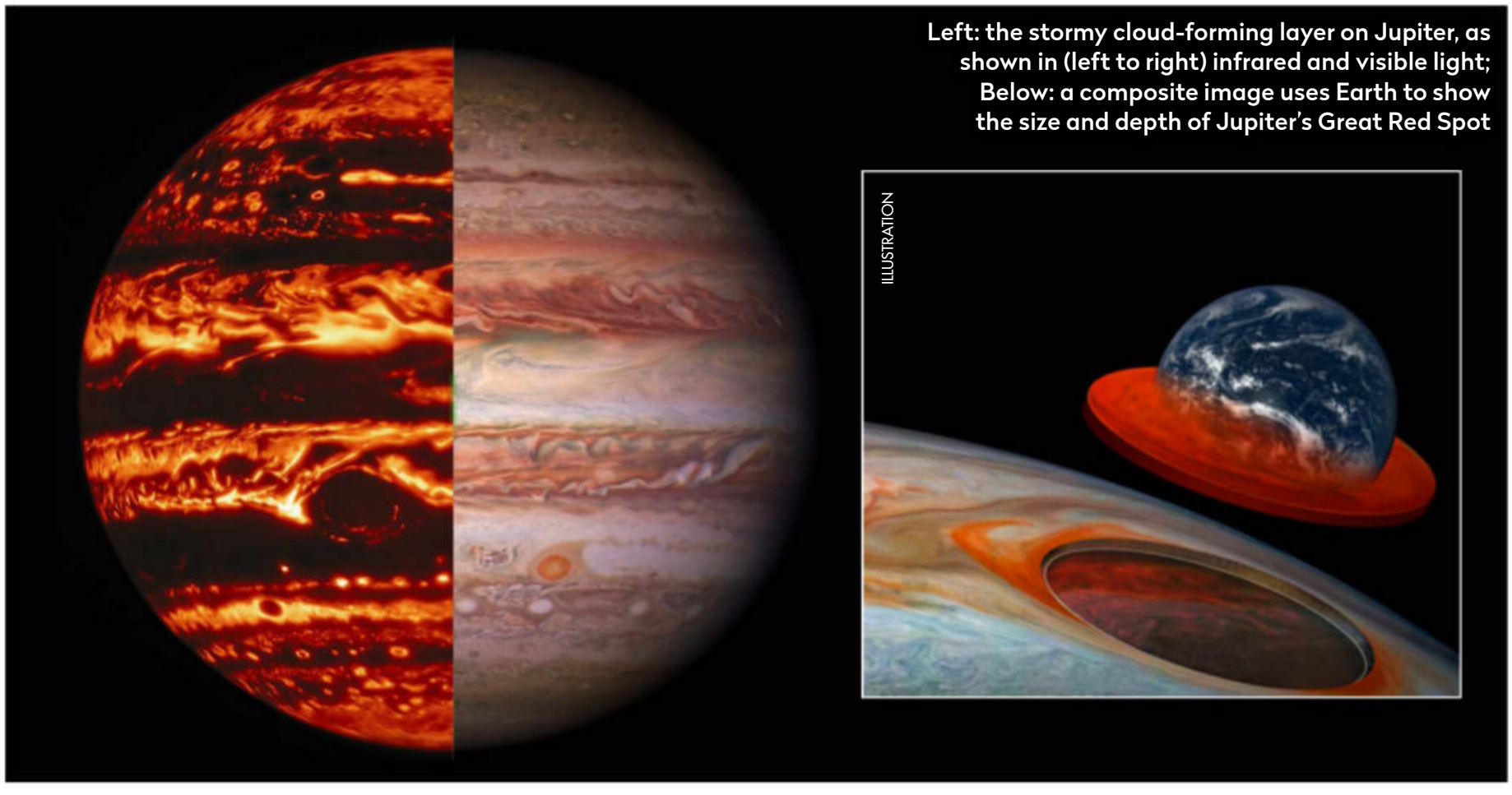
The Great Red Spot extends far deeper than planetary scientists anticipated

A 3D map of Jupiter's atmosphere has given researchers their first view of the inner workings of the planet's belts, zones and cyclones. The map, produced from five years of observations by NASA's Juno spacecraft, reveals that Jupiter's storms extend deeper than expected, including the Great Red Spot (GRS).

Juno arrived at Jupiter in July 2016 and since then it has swooped in close to the planet 37 times. During these manoeuvres, its microwave radiometer looked beneath the upper clouds, examining the structure of the planet's storms, including the Great Red Spot (GRS). The readings found that cyclones are warmer at the top, making them less dense, while their bases are much colder. Meanwhile anticyclones such as the GRS, which spin in the opposite direction, are flipped the other way up.

Juno has also created a map of the planet's gravitational field. As denser areas within the planet's atmosphere have more mass, they will have a stronger gravitational pull, allowing astronomers to work out how mass is distributed. Using this information, they calculated that most storms on Jupiter reached down further than expected – to around 100km – while the roots of the GRS travel down a huge 350km.

"The precision required to get the gravity of the GRS during the July 2019 flyby is staggering," said Marzia Parisi from NASA's Jet Propulsion Laboratory. "Being able to complement the microwave radiometer's finding on the depth gives us great confidence in the results of future gravity experiments."
www.missionjuno.swri.edu



Left: the stormy cloud-forming layer on Jupiter, as shown in (left to right) infrared and visible light; Below: a composite image uses Earth to show the size and depth of Jupiter's Great Red Spot

INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/NSF/AURA/NASA/ESA/M.H. WONG AND I. DE PATER (UC BERKELEY) ET AL, JUNOCAM IMAGE DATA: NASA/JPL-CALTECH/SWRI/MSSS; JUNOCAM IMAGE PROCESSING BY KEVIN M. GILL (CC BY); EARTH IMAGE: NASA

Comment

by Chris Lintott

Being able to fly a spacecraft over Jupiter's Great Red Spot and detect changes in its speed as small as 1mm per second is an impressive achievement.

Juno's precision flying has revealed a planet that is much more complicated than we might otherwise have expected. It's clear that what happens on the surface is influenced by what happens deep beneath the clouds, and vice versa, and understanding the planet as a whole requires attention to be paid to multiple levels at once.

This insight comes from Juno getting up close, and it's clear that modelling Jupiter's weather requires detailed observations.

Spare a thought for those poor astronomers trying to understand distant exoplanets. Seeing Jupiter close up reveals a dynamic and complex story; confidently understanding worlds seen, at best, as points of light is another kettle of fish entirely.
Chris Lintott co-presents *The Sky at Night*

ILLUSTRATION

NOIRLAB/NSF/AURA/J. DA SILVA, DEBORAH FERGUSON (UT AUSTIN) BHAVESH KHAMESRA (GEORGIA TECH) AND KARAN JANI (VANDERBILT UNIVERSITY), SPACEX, UNIVERSITY OF WARWICK/MARK GARLICK

▲ **Researchers had to come up with exotic new names to describe the rich variety of rock types found on exoplanets around white dwarfs**

A planet, but not as we know it

Rocky exoplanets could be far more diverse than the worlds in our planetary system

The rocky worlds of our Solar System could be the odd ones out, as a recent study into the remains of long dead planetary systems has found they were very different to our own.

The discovery was made by astronomer Siyi Xu from NOIRLab and geologist Keith Putirka from California State University, who combined their expertise to investigate the geology of planets around other stars. The duo looked at polluted white dwarfs – the remains of once Sun-like stars that have reached the end of their lives, only to have the planets that once orbited them fall into their atmospheres. The remains of these planets then contaminate the atmospheres of the white dwarfs with elements that wouldn't otherwise be there, but which can be seen in their spectra.

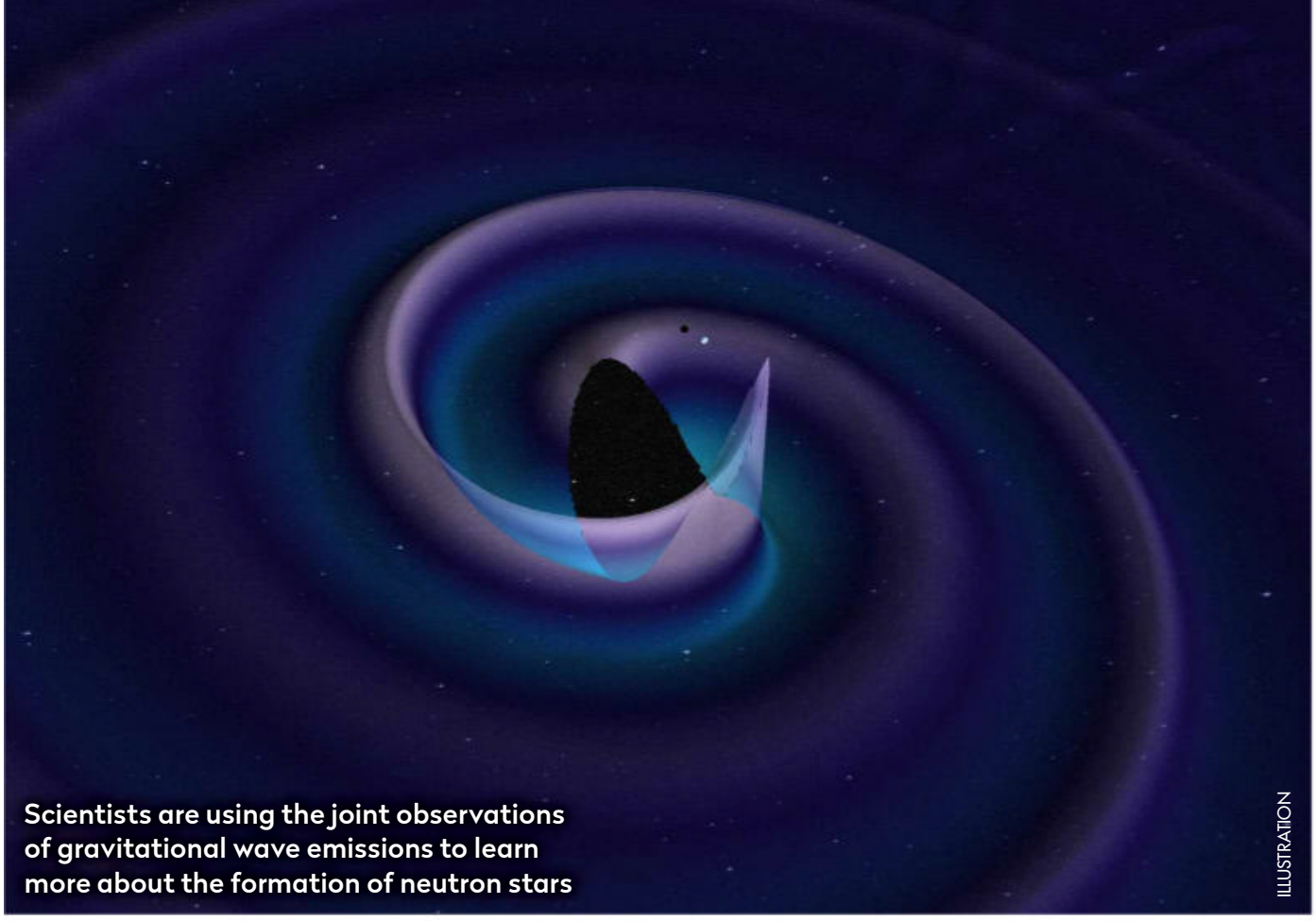
The pair looked at 23 stars using the Keck Observatory to search for geologically important elements – calcium, silicon, magnesium and iron. From this, they were able to piece together what elements, and minerals, the planets were composed of. This showed that most of the planets had a much wider range of rocks than on Earth.

"While some exoplanets that once orbited polluted white dwarfs appear similar to Earth, most have rock types that have no direct counterparts in the Solar System," says Xu.

The differences were so pronounced the pair had to create new names, such as quartz pyroxenites. The disparity could mean other rocky worlds evolve very differently to any of the four terrestrial planets in our own planetary system.

"Some of the rock types that we see from the white dwarf data would dissolve more water than rocks on Earth, which might impact how oceans are developed," says Putirka. "Some rock types might melt at lower temperatures and produce a thicker crust than Earth rocks, and some might be weaker, which might facilitate the development of plate tectonics."

Drawing conclusions about the surface of these planets is hampered by the fact that the minerals that had been observed originated from the planets' inner regions. As the crust is only a small fraction of the planets' masses, their signals were overwhelmed by material from the mantel and core. **https://keckobservatory.org**



Scientists are using the joint observations of gravitational wave emissions to learn more about the formation of neutron stars

ILLUSTRATION

Gravitational wave bounty

Observatories' joint run last summer was the most sensitive yet

The latest catalogue of gravitational wave signals has uncovered 35 new events, bringing the total so far detected to 90. The signals all come from black holes and neutron star mergers, and were detected by the US LIGO, the European Virgo and the Japanese KAGRA gravitational wave observatories during an observing run ending on 27 March 2020.

Among the new discoveries were some rarer events, such as a neutron star being swallowed by a black hole 32 times the mass of our Sun, and the creation of an intermediate mass black hole.

"The new observations continue to challenge our understanding of how stellar-mass black holes and neutron stars form, and how they come to orbit each other until they merge," says Alessandra Buonanno from the Max Planck Institute for Gravitational Physics.

The observatories are shut down for upgrades, but will recommence operations in late 2022. **www.ligo.caltech.edu**

Return to the Moon pushed back

A human lunar landing might have to wait, as NASA has put the launch date for its Artemis III mission back to no earlier than 2025.

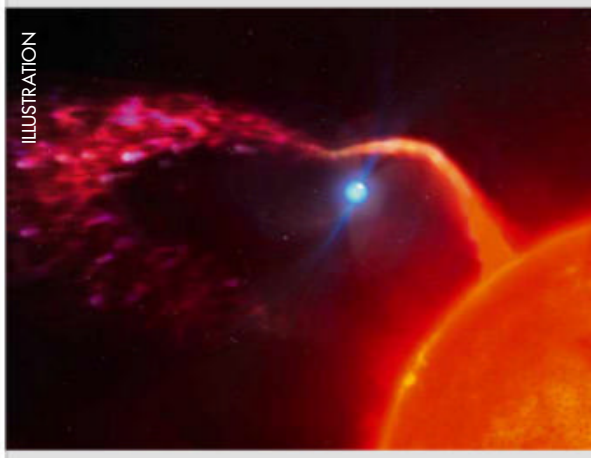
The delay of NASA's human Moon landing until 2025 will give other nations a chance to catch up

ILLUSTRATION

The programme was initiated in 2017 by the Trump administration, with the goal of putting the first woman on the Moon by 2024. But the project has been subject to many delays – from cost and supply issues due to the pandemic, to flood damage at the Michoud Assembly Facility, where the Space Launch System rocket is being assembled. In addition, progress on the Human Landing System being built by SpaceX is being hampered due to litigation from rival spaceflight company Blue Origin. The first stage of the mission, the uncrewed test flight Artemis I, is currently undergoing final preparations before launch in early 2022, several years behind its initial launch date.

The delays have given a window for other nations with their eyes on lunar exploration to catch up. In November, Senior Chinese lunar programme designer, Ye Peijan, said, "A Chinese crewed Moon landing is entirely possible by 2030." **www.nasa.gov**

NEWS IN BRIEF



ILLUSTRATION

Stellar propeller

The fastest spinning white dwarf ever seen has just been clocked in at one rotation every 25 seconds. The star is the second known example of a magnetic propeller, meaning its spin is powered by pulling material from a nearby companion star and then flinging it into space at 3,000 km/s.

DART launches

NASA's Double Asteroid Redirection Test (DART) successfully launched on 24 November and is now on its way to the binary asteroid Didymos. In September 2022, the spacecraft will collide with the smaller of the pair, altering its orbit to test if the same technique could one day be used to deflect an asteroid on a collision course with Earth.

Distant water

Water has been detected in a galaxy whose light left it when the Universe was just 780 million years old – earlier than previously thought possible. An explanation could lie in the fact it is undergoing a merger, which could be speeding up star formation to create enough oxygen to form H_2O.

NEWS IN BRIEF

Chip off the old Moon

Recent spectral analysis of near-Earth asteroid Kamo'oalewa shows it has a similar composition to the Moon, suggesting it could have been chipped off by an impact. The space rock is around 50m in size and is a quasi-satellite, meaning it takes the same time to orbit the Sun as Earth does, but along a different path.

Hubble's future

Funding for the Hubble Space Telescope has been extended to June 2026. However, the telescope has entered safe mode multiple times over the last year, the most recent of which occurred on 25 October. Though it did recover, it raises questions over how long the telescope will last.

Uncovering habitable planets

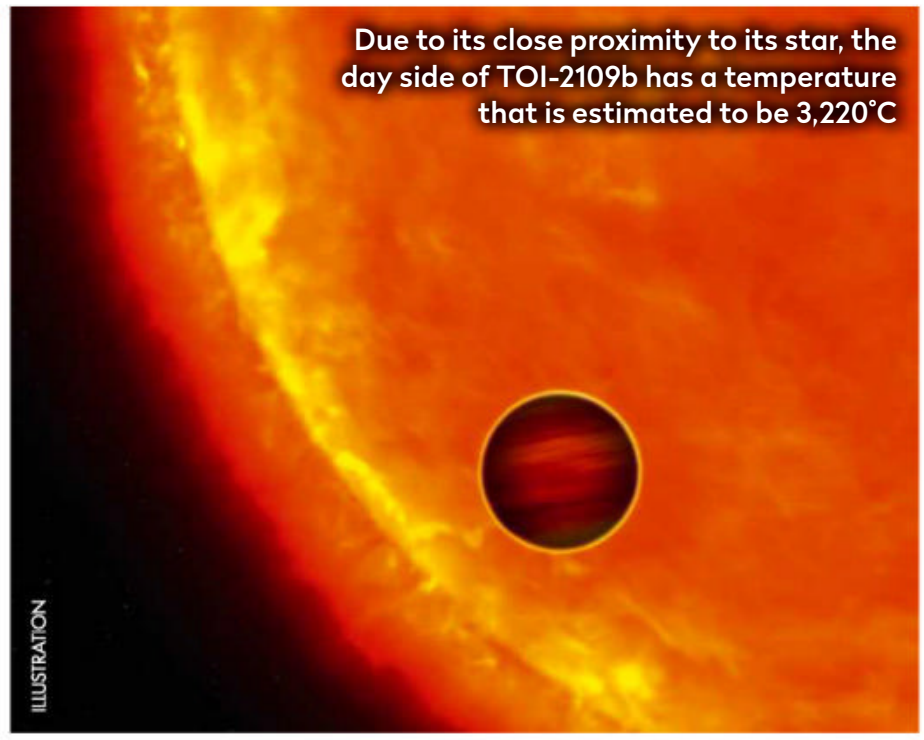
A new mission is set to discover whether any of our nearest neighbouring stars have planets like our own. The space telescope, called TOLIMAN, will look for rocky planets in the 'goldilocks' zones of their stars, where liquid water can pool on the surface.

ADDY GRAHAM/UNIVERSITY OF ARIZONA, NASA'S GODDARD SPACE FLIGHT CENTER, NASA/CHRIS GUNN

BULLETIN

An orbit in less than a day

This speedy planet could be spiralling in towards its star



Due to its close proximity to its star, the day side of TOI-2109b has a temperature that is estimated to be 3,220°C

A newly discovered planet has a 'year' that is just 16 hours long, the quickest orbit of any so-called 'hot-Jupiter' – a gas giant with an extremely short orbit – ever discovered.

The planet, TOI-2109b, was discovered by the exoplanet-hunting satellite TESS. It is around five times the mass of Jupiter and just 2.4 million km away from its star. Its course is so tight that the planet is probably in a 'decaying orbit' and spiralling in towards its star at the centre of its system.

"In one or two years we may be able to detect how the planet moves closer to its star," says Ian Wong, who led the study at the Massachusetts Institute of Technology. "In our lifetime we will not see the planet fall into its star. But give it another 10 million years, and this planet might not be there."
https://tess.mit.edu/

Missile creates new cloud of space debris

A Russian anti-satellite test created over a thousand pieces of new space debris on 14 November. The next day, the cloud passed close enough to the International Space Station that the crew were forced to shelter in their capsules. The move has been condemned by many nations for exacerbating the existing problem of space debris.

▲ **Near-Earth orbital debris is a growing problem – there are now around 36,500 objects larger than 10cm in orbit**

"This destructive anti-satellite missile test by Russia shows a complete disregard for the security, safety and sustainability of space," says the UK's Defence Secretary, Ben Wallace. "The debris resulting from this test will remain in orbit, putting satellites and human spaceflight at risk for years to come."

Space debris, consisting of fragments of old satellites that have the potential to destroy functioning ones, has been a growing issue as more items are launched into space. Just four days before the test, the ISS had to perform an emergency manoeuvre to avoid another piece of space debris created by a Chinese anti-satellite missile test from 2007. Russian defence minister Sergei Shoigu, however, maintains that the fragments from their test, "...do not pose any threat to space activity."

JWST readies for launch

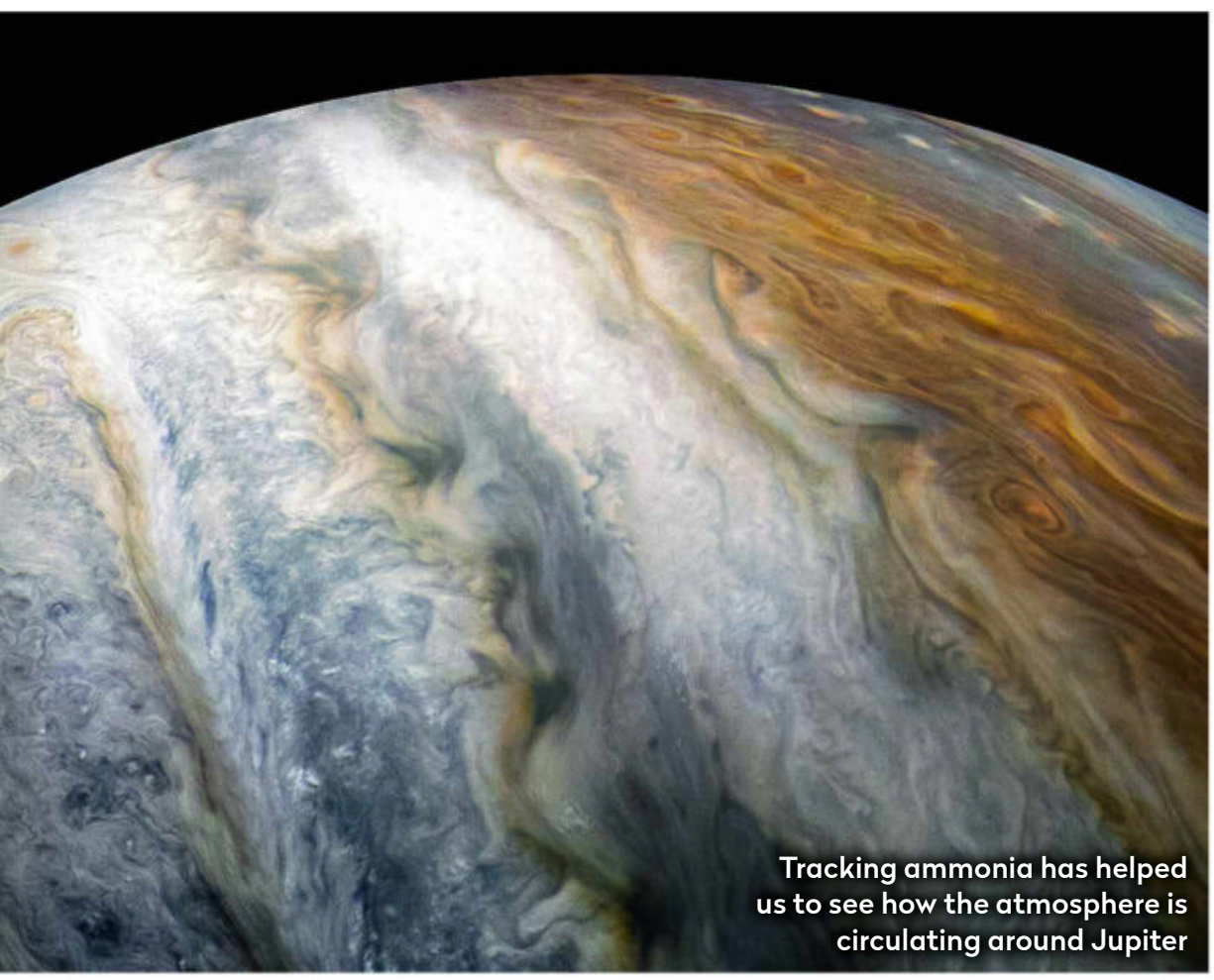
After three decades of planning, designing and building, the James Webb Space Telescope (JWST) is finally due to head to orbit from Europe's Spaceport, the Guiana Space Center in French Guiana – albeit three days later than expected.

The spacecraft is a 6.5m-wide infrared telescope, capable of observing the Universe from the first glow of the Big Bang to planets growing around stars today. Both the spacecraft and its tennis-court sized Sun shield have been folded up to fit inside the Ariane 5 rocket it will launch aboard. However, in late November, a clamp band unexpectedly released, vibrating the observatory.

The JWST is designed to survive much more vigorous shaking during launch, but NASA pushed its launch date back to 22 December to allow for additional checks to ensure everything is well with £10 billion spacecraft.

Our experts examine the hottest new research

CUTTING EDGE



Tracking ammonia has helped us to see how the atmosphere is circulating around Jupiter

NASA/JPL-CALTECH/SWRI/MSSS/KEVIN M. GILL, OZGRAV/ SWINBURNE UNIVERSITY OF TECHNOLOGY

The winds of Jupiter

Juno is helping to reveal how the gas giant's atmosphere circulates

The pattern of circulation in Earth's atmosphere is pretty straightforward. The Sun warms air around the equator that rises, then rolls over through high altitudes before sinking down to the ground at latitudes near 30° north and south (around a third of the way to the poles). From there the moving air blows across Earth's surface back to the equator. This is a giant convection current – just like the one that churns over the radiator in your living room – and the pair straddling Earth's equator are called the Hadley cells.

There are three great atmospheric circulation cells in each of Earth's hemispheres. The middle cell of each trio (called the Ferrel cell) is driven round by its neighbours like a cog. Since all of this results in a flow of the atmosphere across latitudes between the equator and pole, the system is known as meridional circulation and it creates the prevailing winds, such as the trade winds and westerlies.

The stripey appearance of Jupiter is also believed to be due to meridional circulation in the atmosphere, but this is much more obvious than on Earth because the rising and sinking regions of Jupiter's atmosphere cause conspicuous differences in the cloud layers and colours. The horizontal pale 'zones' are caused by upwelling and the formation of high-altitude ammonia ice, and the 'belts' are ruddy-coloured clouds where the air is descending. There are also powerful jet streams in between.

Beneath the clouds

What we don't know, however, is what happens to these circulation cells deep in Jupiter's interior – there's no solid lower boundary like there is with Earth's surface. Keren Duer, at the Weizmann Institute of Science in Israel, and her team have been using data returned by the Juno mission to try and find out. Since 2016, when it arrived at Jupiter, NASA's probe has been measuring the light being reflected off the gas giant at different wavelengths, including infrared and microwave. Any light that's able to penetrate the top cloud layer allows us, to some degree, to peer into the planet's interior.

By looking at the microwave data from Juno, the team was able to track the ammonia in Jupiter's atmosphere. This revealed the presence of a series of regions of upwelling and downwelling hidden beneath the visible upper clouds in the mid-latitudes of Jupiter – between 60° south and 60° north. These form eight deep circulation cells in each hemisphere of the planet, like a whole set of rollers side-by-side. And, in a similar way to the middle Ferrel cell in each of Earth's hemispheres, Jupiter's mid-latitude circulation cells are driven by active convection at the equator. However, while Earth only has one Ferrel cell in each hemisphere, Jupiter has eight due to its larger size and faster spin.

"This only allows detection down to a few hundred kilometres below the cloud decks, so we know Jupiter's Ferrel cells extend at least as far as that"

Duer's team was able to trace these deep meridional circulation cells by observing ammonia in the microwave data. This only allows detection down to a few hundred kilometres below the cloud decks, so we know Jupiter's Ferrel cells extend at least as far as that. It's not the whole story, but it goes a long way towards understanding the atmospheric dynamics hidden beneath Jupiter's clouds.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Evidence for multiple Ferrel-like cells on Jupiter* by Keren Duer et al.
Read it online at: arxiv.org/abs/2110.07255

Finding a home for fast radio bursts

Tracing the source of one of the bursts solves part of the mystery of these short, energetic events

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Since their discovery in 2007, fast radio bursts (FRBs) have continued to fascinate, not least because they have avoided simple explanations. These sudden and intense flashes of radio waves, detected by telescopes around the world, often seem to be one-off events, suggesting some sort of catastrophic explosion such as an extreme supernova might be responsible. But some repeat, occasionally on a regular pattern.

The fact that these things are fast, lasting just milliseconds, and bright, emitting a huge amount of energy, makes most people think they're related to compact objects, such as neutron stars or black holes (colliding neutron stars seem to fit most of the observed properties of at least some bursts). Other suggestions – from active galactic nuclei to misbehaving pulsars to exotic behaviour in string theory – abound in the scientific literature.

One of the problems is that although there's good evidence to suggest most FRBs are distant, identifying their host galaxies is hard. That's why I'm excited by this month's paper, which takes a close look at one burst and manages to find its home.

"One of the problems is that although there's good evidence to suggest most FRBs are distant, identifying their host galaxies is hard"

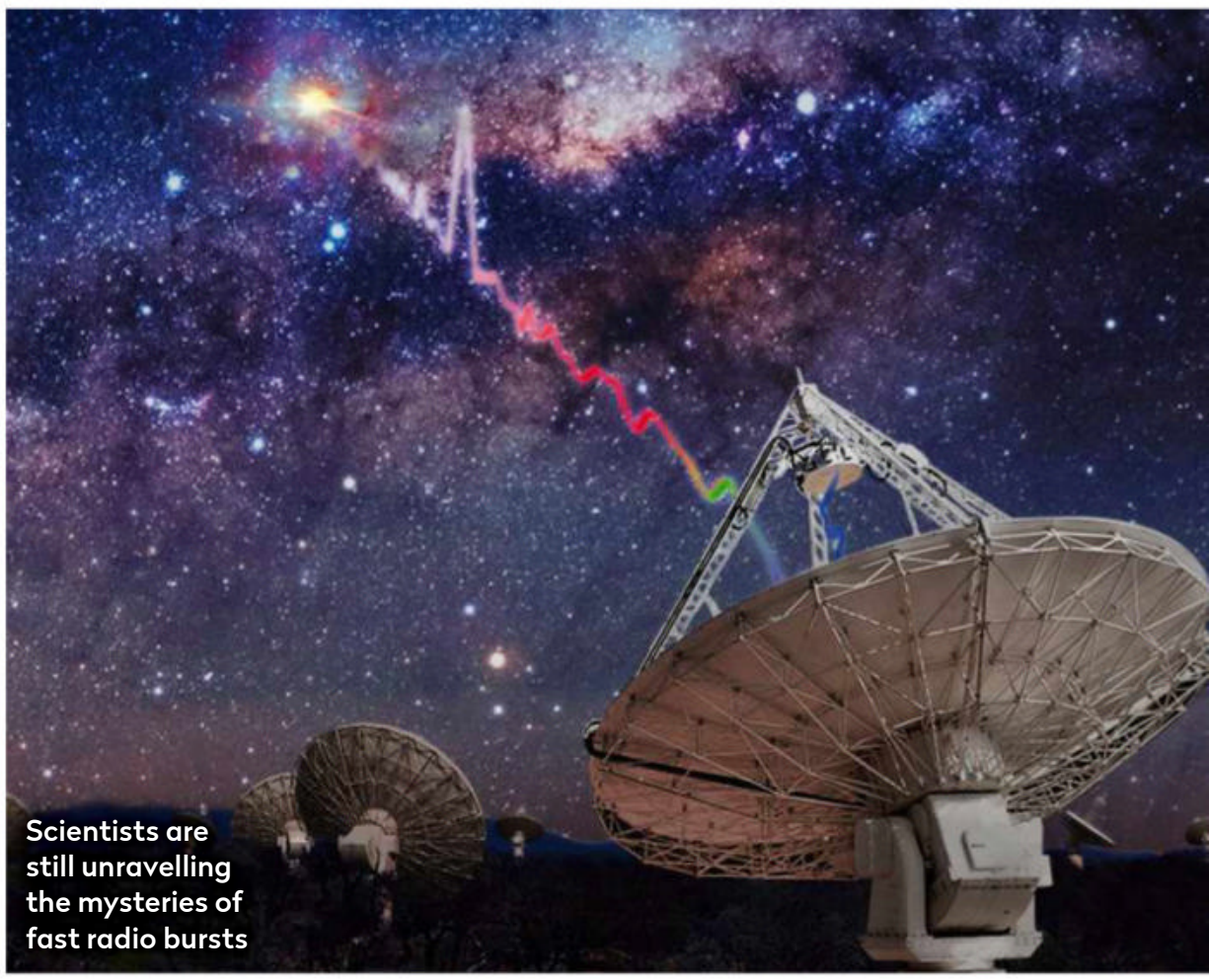
Closer than you might think

FRB 20181030A has been detected nine times by the Canadian Hydrogen Intensity Mapping Experiment (CHIME) telescope, the world's premiere FRB-hunting instrument. Because it has been observed so often, the burst can be traced to a much smaller region of the sky than normal – a region that contains seven known galaxies; one of which, NGC 3252, is much closer than the others. The odds of having a system that close – just 65 million lightyears away from the Milky Way (a stroll to the shops in galactic terms) – to where the FRB occurred by chance is estimated to be around 1 in 400, making this one of the closest FRBs to have a host galaxy determined.

In fact, two other repeating bursts have been found closer than this one and combining the three allows us to estimate how common they really are. It turns out that by doing so we can rule out some of the most popular potential culprits. People have blamed FRBs on a form of rapidly spinning, magnetically active neutron star known as a magnetar, but there aren't nearly enough of these to account for even the three nearby examples we see.

On the other hand, all of the five repeating FRBs whose host galaxies have been traced live in spiral systems. This might be an excellent clue: spirals tend to host supernovae caused by the collapse of massive stars (except that one of the five is from a globular cluster in M81, a place where there should be no such events). What's more, all of the five are (relatively) low-energy events – much less spectacular than the cosmic beacons seen in the more distant Universe – so there may be more than one mechanism at work.

FRBs are a proper cosmic mystery, with astronomical detectives still very much on the trail of whatever is causing these spectacular events. Identifying the host of this particular burst is a big step forward, but there's a lot more still to discover.



ILLUSTRATION

Scientists are still unravelling the mysteries of fast radio bursts

Chris Lintott was reading... *A Local Universe Host for the Repeating Fast Radio Burst FRB 20181030A* by M. Bhardwaj et al. **Read it online at: ui.adsabs.harvard.edu/abs/2021ApJ...919L..24B/abstract**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

▲ **Producer Peter Leonard (far left) in action, as Chris Lintott is filmed at Herstmonceux Observatory Science Centre for the November 2021 episode of *The Sky at Night***

JOHN FOX/FRAS, LIANG WU//ISTOCKL/GETTY IMAGES, JORDON SHARP/ISTOCKL/GETTY IMAGES,

As *The Sky at Night* looks back at the programmes in 2021, producer **Peter Leonard** reflects on the role the show has played in his career

Since March 2021, I've been the series producer of *The Sky at Night*. It means that I've had to learn a lot about astronomy and space science very quickly in order to research, plan, shoot and edit the show every month. But it's been great fun and a privilege to take my place in the unbroken chain of people who have been doing this job for 65 years. But although I only started in the role this year, my connection with the show goes back to nearly the start of my working life, in the early 1990s.

I was working at the BBC's Television Centre in London, desperately trying to get promoted. I wanted to be a videotape editor – someone who puts shows together, cuts things out, smooths things over, adds captions and gets on-screen credits. However, back then it was widely accepted that it would take at least 10 years to reach the giddy heights of videotape editor, and I only had a handful of years under my belt. But one evening, fate smiled on me. "We've got a simple edit job that needs doing in VT5", my supervisor said. "All the editors are busy. Do you fancy having a go?"

"Yes, of course," I lied.

"It's for *The Sky at Night*," he went on. "They want to change a couple of shots. Don't mess it up."

Making changes

Petrified, but realising that this was a 'now or never' moment, I hurried off to meet my fate. And although it was a simple job, I managed to make it look complicated. But Pieter Morpurgo (the then producer and without doubt the nicest man in television) was very good about my fumbling and lack of experience.

The show has changed hugely in the 30 years or so that have passed since I first 'worked' on it. Videotape is now largely a historical curiosity, and far from being mostly studio-based, the programme is now filmed on location, taking viewers to the people

Peter Leonard is the series producer of *The Sky at Night*

and places that bring further dimensions to the experience of looking at the night sky. And, thanks to the rise and reliability of video calls, we've met astronomers and scientists across the world, from NASA to New Zealand. You certainly couldn't have done that in the 1990s!

This month's episode is our review programme, where we feature some of the highlights of the year. And what a year! We'll be looking back at NASA's latest Mars mission (Perseverance) and looking ahead to the JUICE (JUpiter ICy moons Explorer) mission, as well as updating some of our stories, such as Anglo-Japanese company Astroscale's attempts to clean up low-Earth orbit. Other highlights include a new report on ESA's BepeColombo mission to Mercury, another chance to see some of Herstmonceux Observatory Science Centre, and a remarkable story of seeing Jupiter and its moons at the Cricket World Cup.

Though I could never have imagined I'd be able to say it back in that edit suite with Pieter Morpurgo, it's very good to be back.

This, my latest encounter with the programme, started with a phone call last February. "We need a series producer for *The Sky at Night*," they said. "Do you fancy giving that a go?"

"Yes of course," I said. Truthfully, this time.

Looking back: The Sky at Night

10 January 1982

On the evening of 9 January 1982, a blood red Moon was seen in the sky above the UK, as a total lunar eclipse passed overhead. The next day, on *The Sky at Night*, Patrick Moore talked the public through the features they'd seen the previous night, using footage recorded by a special camera set up on top of London's Television Centre.

▲ **With Earth's atmosphere in its path during an eclipse, only red light is able to reach the Moon**

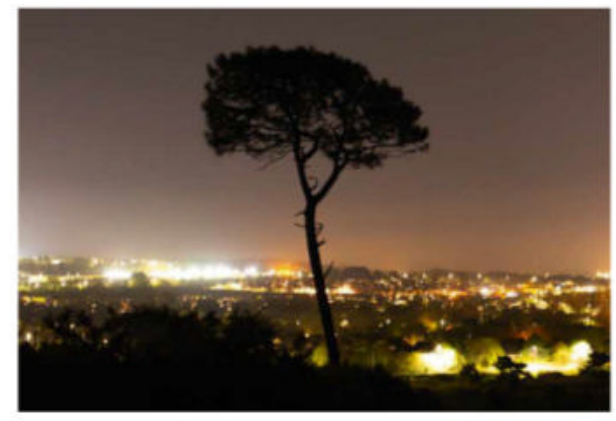
A lunar eclipse occurs when the Moon passes through Earth's shadow. But this shadow doesn't have a hard edge, due to Earth's atmosphere diffusing the light. In the outer portion of the shadow, known as the penumbra, Earth only partially shadows the Sun. Meanwhile, the inner portion of the shadow, known as the umbra, is lit by sunlight bent by the atmosphere. As the air scatters away the blue part of the spectrum, this region takes on a red glow.

Patrick showed viewers footage of the lunar eclipse, pointing out that when the Moon passes through the penumbra, the lunar disc dims while a portion of the surface fades into darkness. Then, when the Moon passes into the umbra it reappears again, but this time its familiar grey is replaced with a rust red. Finally, the Moon passes back into the penumbra before leaving the shadow entirely, and the eclipse is over.

Dark Skies

Light pollution can make life very difficult for astronomers. In this episode the team speak to ecology experts, radio astronomers and dark-sky rangers to find out why light pollution is such an issue, whether it's getting worse and what we can do about it. Plus, the London-based Baker Street Irregular Astronomers reveal how they observe the night sky from a light-polluted area.

BBC Four, **9 January**, 10pm (first repeat BBC Four, **13 January,** 7:30pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information



▲ **The glow from light-polluted urban areas makes it difficult to observe the night sky**

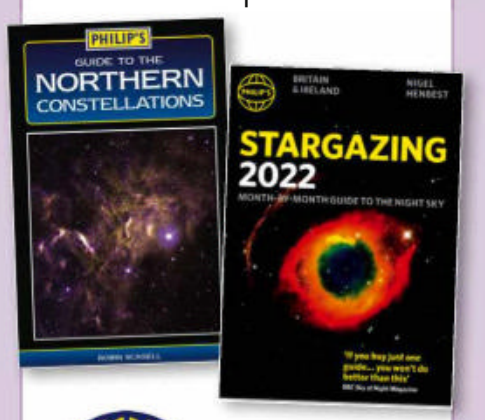
Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles



The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Rates of expansion

I would like to raise a question about the Hubble Constant. I have been reading about the discrepancy with this – in that the further away we look, the quicker galaxies are moving apart – but, every explanation presents the theory of dark energy to explain the discrepancy.

In my layman's mind surely the discrepancy is explained because the expansion of the Universe is slowing down and not accelerating? My rationale is that the further away we look, the further back in time we are looking, and the expansion is faster there, so does that not mean that the expansion is slowing down? I have not seen an explanation that spells out why my thinking is wrong; none mention time as a factor to be discounted. I am not looking at the detailed science, as I would not know how to start; that's why I am hoping to see an answer that explains why I am wrong and puts me back in my place as an IT guy!

Stuart Buchanan, via email.


ILLUSTRATION

▲ Is the cosmos really accelerating? Stuart raises an interesting query about the Hubble Constant

Thank you for your thought-provoking message, Stuart! Scientists do take time into account when they're looking at the expansion rate of the Universe over cosmic distances, with what's known as the Hubble Parameter. Roughly speaking, this shows changes in the expansion rate over time, while the Hubble Constant is the expansion rate at a specific point in time – now. As the Hubble Constant is a greater value than the Hubble Parameter in the past, it implies that the expansion rate is accelerating. ***– Ed.***

Tweet

StrollingShuttereyes
@strollingshutte • Nov 22
From a vantage point above Bde Maka Ska [in Minnesota], I took a composite image showing the phases of the partial lunar eclipse from start to peak. Enjoy! @skyatnightmag #LunarEclipse2021

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO

Ready for Xmas

Using my Canon EOS 600D DSLR camera and a standard lens, this was a hastily grabbed shot of the Moon as it was rising over the rooftops. I even slightly overexposed the Moon to give the effect of a Christmas tree with a giant light on the top branch. It's the ultimate Christmas decoration!

John Consadine, Dereham, Norfolk

Lost in space

In Chris Lintott's 'Comment' in the December 2021 issue ('Bulletin', page 11), he mentioned the Huygens spacecraft nearly missing out on sending data back from its landing on Titan. There was also another issue with the mission: Huygens was supposed to send back 700 photos during its descent, using two channels, A and B, so that one photo would go into channel A and the next would go into channel B. But Cassini was missing the command to turn on channel A, and the

Daniel's early morning shot of the Moon with Mercury over Glasgow

700 photos from Huygens all went into channel B's 350-photo storage location. As only 350 were stored, one photo overwrote the other and half were lost forever.
John Fairweather, via email

Morning pair

I was woken early by my son and was treated to an unexpected clear morning, giving great views of Mercury and the crescent Moon over Glasgow (pictured, above). I was unprepared, but managed to grab my camera and get some photos before Mercury faded into the dawn.
Daniel Gilroy, Glasgow

By Jupiter!

I have no more than a layman's understanding of astronomy, and one thing that often baffles me is how ancient astronomers knew so much about our Solar System. For example, ancient Greek and Roman civilizations conflated planets with deities – Mars, the god of war; Venus, the goddess of love and beauty; Mercury, the god of commerce and communication, and so on. They ascribed supremacy to Jupiter and endowed that god with specific properties (such as Jupiter's ancient Greek equivalent, Zeus, assuming many disguises), which are remarkably close to the properties of that planet discovered later with modern technologies.

How did the ancient Romans know that Jupiter was the largest planet in our Solar System when they didn't have telescopes? To some extent the properties of Mercury, Venus and Mars are less baffling and could be the result of simple observations like the speed of Mercury across the sky, the beauty of ▸

ON FACEBOOK

WE ASKED: What are your New Year's resolutions for 2022?

Carol Miller I don't normally do New Year's resolutions, but I want to learn more about the Sun. I'm fascinated by recent sunspot and solar flare activity and, as I have a solar filter for my telescope, I want to record sunspot activity and changes.

Gary Anderson Now I have my mini-Dobsonian, my New Year's resolution is to make use of every clear night.

Martin Jørgensen To get out more, and look up more!

Kriss Jupiter Appear on *The Sky at Night* programme and say, "Don't forget, keep looking up" (hint hint! I don't think Maggie and Chris would mind).

Steve Walker Sort out my guiding and get to grips with my imaging setup; possibly invest in a new imaging telescope.

Maad Khalil If I don't manage it before the end of 2021, I would like to be able to see and identify the location of the planets Mars, Neptune, Uranus and Mercury.

Youdhisthir Rai I would like to try and collect pictures of all my favourite objects.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I have an Altair refractor telescope on a Sky-Watcher AZ-EQ6 Go-To mount. Can I leave this outside or will the damp be a problem?

STEWART BALL

▲ A telescope cover such as the TeleGizmos 365-series will help protect your equipment outside

Leaving a mount and telescope outside in the open is always going to be problematic, but the advantage of instant access and consistent polar alignment may make it worthwhile for you. However, the risk regarding dampness should not be underestimated: mount electronics, fixings and telescope optics will not respond well to moisture.

A multi-pronged approach to protection can make all the difference, by tackling various issues separately. Starting at the core of the system, using an anti-corrosion treatment like ACF-50 spray on the mount, fixings and electrical connections will make a difference to their long-term reliability. The internals of the telescope can be protected with a desiccant cap like the Astro Essentials Dual-Fit or Farpoint 1.25- and 2-inch Desiccant Caps, installed in the eyepiece holder. Moving outwards, a soft breathable material cover over the complete system will protect your gear from abrasions. To top this off, a breathable, water-repellent and UV-resistant cover from TeleGizmos or Cygnus Astro Covers will offer a final layer of protection.

Steve's top tip

What is a Barlow lens?

The magnification of a telescope-eyepiece combination is calculated by dividing the focal length of the scope by the focal length of the eyepiece, so increasing the scope's focal length will increase the magnification. The actual focal length of a scope is fixed by the design of its optical components, but the effective focal length can be altered with optical attachments.

The Barlow lens, an optical tube containing lens elements that diverge the light passing through them, increases the scope's effective focal length, normally by a factor of two, though there are some designs that can have a greater effect.

WWW.FIRSTLIGHTOPTICS.COM

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE IMMEDIATE MEDIA Co

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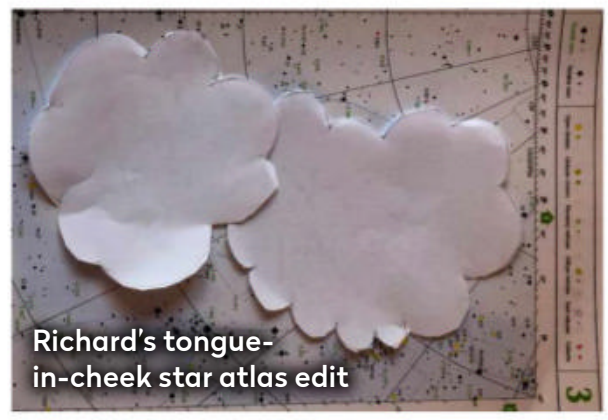
▸ the evening star, or the red colour of Mars. But surely Jupiter and the outer planets were only dots of light to the Romans?
Syd Palmers, via email

Reality check

I have found the sky charts in the otherwise excellent *Cambridge Double Star Atlas* to be rather inaccurate for observers here in the northwest of England. In an attempt to improve matters, I have developed a simple aid (below) which addresses this shortcoming!
Richard Newstead, Macclesfield



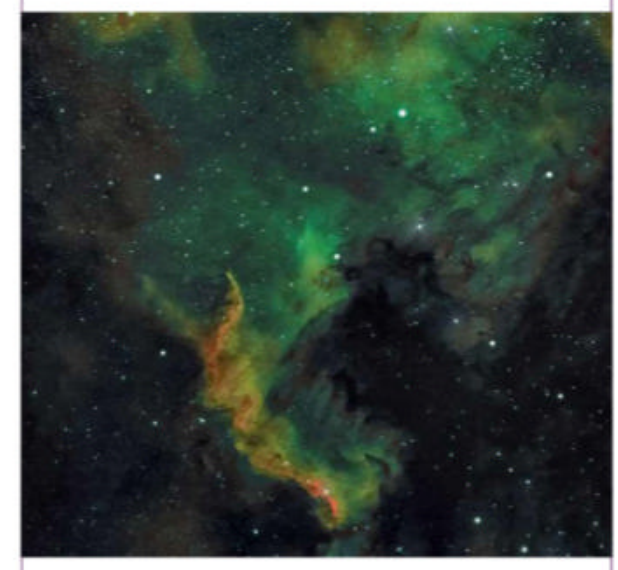
Richard's tongue-in-cheek star atlas edit

CORRECTION

• In the second part of 'DIY Astronomy, Build a roll-off roof garden observatory' (December 2021 issue, page 76), it incorrectly states that the observatory's runner "...is supported by corner posts and a 100mm^2 fence post." This should be a 100mm square fence post.

Instagram

alba_astrophotography
• 22 November



Last night I was blessed with a crystal clear sky here in Loch Lomond, albeit rather frosty and cold. There was no way I was passing up what has become a rarity of a clear night. Here is just one of the many deep-sky objects I shot over the course of the night – the Cygnus all of the North America Nebula – processed a la Katie. @bbcskyatnightmagazine @firstlightoptics @astrobackyard #astronomy #astrophotography #darkskies #cosmos #universetoday

SOCIETY IN FOCUS

In October, **York Astronomical Society** (YAS) organised an evening of music and astronomy with the York Railway Institute Band. The collaboration between two historical York societies created an inspiring atmosphere. The brass band played a wide variety of music inspired by the night sky, each piece accompanied by a backdrop of images of planets, galaxies and nebulae captured by the Hubble Space Telescope and YAS members. Music ranged from Holst's *The Planets* to David Bowie's 'Life On Mars'.

YAS was formed in 1972 by a group of enthusiasts in response to the excitement generated by the Apollo Moon landings, and is now a registered charity (#1174488). We currently have 77 members, many of whom have an expert knowledge of the Moon and deep-sky objects. Many are also astrophotographers, with a keen interest in live stacking and plate-solving using the ASIair Wi-Fi control unit.

We meet twice a month, and run an

▲ **The YAS evening of astronomy and music featured space-themed tunes**

outreach programme in which we host schools and other local groups at our observatory on the outskirts of York. We also hold public star parties in and around York, including at Fountains Abbey. In October we held an event at Sutton Bank to celebrate the North York Moors achieving International Dark Sky Reserve status. The skies were crystal clear and many members of the public joined YAS members in enjoying spectacular observing and imaging opportunities.
Freda Rockliffe, YAS committee member for outreach
▸ **www.yorkastro.org**

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Live New Dark Sky Discovery trail

Larkbarrow, Exmoor National Park

A night-walking trail has been unveiled at the heart of Exmoor National Park. The flat there-and-back-again route across fields is 3.2km-long, starting from Larkbarrow near Exford, and it offers 360° panoramas of some truly dark skies. **exmoorwalks.org/darksky**

Live Astronomy and Islam

Royal Observatory Greenwich, 2 January, 10:30am

Hear about the characters depicted in the stars in Arabic astronomy lore and the importance of Moon phases in Islam in this one-hour show. Ages 7 and up. Adults are £10, children £5, including entry to the Observatory. **www.rmg.co.uk/whats-on**

Online Astrophysics talk

14 January, 7:45pm

In his talk 'The Standard Model and Possible New Physics', author Harry Cliff looks at the quest for a single 'theory of everything' to explain how the Universe works. Non-members £3 donation. To join the Zoom, contact **membersec@midkentastro.org.uk**.

Online The Sky: Why it Matters and How We Might Lose It

20 January, 7:30pm

Professor Andy Lawrence looks at how the drive for fast internet speeds is putting the night sky under threat as tens of thousands of satellites are slated for launch. See the Astronomy Society of Glasgow's YouTube channel at **https://bit.ly/ASofGlasgow**

AMANDA SMITH/MATT BOTHWELL, YOUTUBE/INSTITUTE OF ASTRONOMY

PICK OF THE MONTH

▲ The online archive of the Institute's lectures is available for free on YouTube

Online Institute of Astronomy open evenings

From cosmic rays to gravity, catch a new talk on the latest astronomy research each week

Every Wednesday throughout the winter season (until 23 March 2022), the Institute of Astronomy at the University of Cambridge opens its virtual doors to the public for an evening lecture and stargazing session (weather-permitting).

It's online only for now, but hybrid live and virtual events are planned. Fast radio bursts will be the lecture topic on 19 January at 7:15pm. Watch live and join in the Q&A or catch up with all the recent Institute of Astronomy videos on Youtube, including talks on cosmic rays, exoplanets, star dust, planet and galaxy building, and much more at **https://bit.ly/InstituteofAstronomy**

Online Medieval astronomy

22 January, 8pm

Dr Philipp Nothaft looks at 12th-century astronomer Walcher of Malvern, an early European adopter of the astrolabe and one of the first English astronomers to embrace Arabic science. For Zoom details, contact: **meetings@shastro.org.uk**

Live Public observing evening

Beachy Head Story Centre, Eastbourne, 22 January, 5pm

Take a look through Eastbourne Astronomical Society's telescopes, hear all about night-sky targets from the club's expert members and enjoy an introduction to astronomy presentation. Free. **www.eastbourneas.org.uk/practical-observing**

Live Observatory night

Breckland Observatory, Great Ellingham, 28 January, 7:30pm

Join astronomers from Norfolk's Breckland Astronomical Society for a public evening viewing planets, stars, galaxies and more. Free. Contact: **visitors@brecklandastro.org.uk**

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The amateur astronomer's forum

FIELD OF VIEW

How to get started in astronomy

In the magazine's first issue, **Patrick Moore** championed amateur stargazers

Always an avid practical astronomer, Patrick (seen here in 1975) dedicated his life to the pursuit of the hobby

KEYSTONE/STRINGER/GETTY

There was a time not so long ago when astronomy was regarded as a subject divorced from everyday activities. The picture of a typical astronomer conjured up an old man with a long white beard, spending his time in a lonely observatory. That picture was never accurate and today it could not be further from the truth – professional astronomers spend relatively little time inside observatories and almost never look directly through a telescope. It is only amateurs who carry out old-fashioned observations.

Yet the contributions made by amateurs are as important now as they ever were and are widely welcomed. This is a state of affairs probably not found in any other branch of science. Amateurs hunt for comets and exploding stars, monitor variable stars, routinely observe the surfaces of the planets, obtain records of meteor showers and aurorae, and much more.

Amateurs of today use equipment that enables them to match the results of major observatories when I first became interested. Elaborate, expensive equipment is quite unnecessary for some branches of research and anybody who wants to take a real interest needs nothing apart from enthusiasm and adequate eyesight.

Sir Patrick Moore (1923–2012) was the Editor Emeritus of this magazine, President of the British Astronomical Association and Society for Popular Astronomy, and a researcher and writer of over 70 books. He presented *The Sky at Night* on BBC TV from 1957–2012

Quite apart from this, there are many folk who are anxious to take more than a passing interest in the skies, but who have absolutely no desire to do anything in the nature of scientific work. After all, who can fail to be fascinated by what is happening 'up there'? Astronomy can take as much or as little time as required. In this magazine we aim to cater for people of all ages and all interests.

So if you want to start taking a real interest in astronomy, how do you go about it? I can answer the question with authority because I have been down that road myself. First I did some reading and made myself familiar with basic facts. Next, I obtained an outline star map and learned my way around the night sky, which is not nearly so difficult as it might seem because the stars do not change position relative to each other.

I used to go out after dark, when the sky was clear, and made a pious resolve to learn one new constellation every night. Within months I had an adequate working knowledge, and the stars become much more interesting when you know which is which.

Only the planets wander around and each has its own distinguishing characteristics: Venus and Jupiter are brilliant and Mars is red, while you are quite unlikely to see Mercury unless you are deliberately looking for it. Only Saturn and Mars at its faintest can cause confusion.

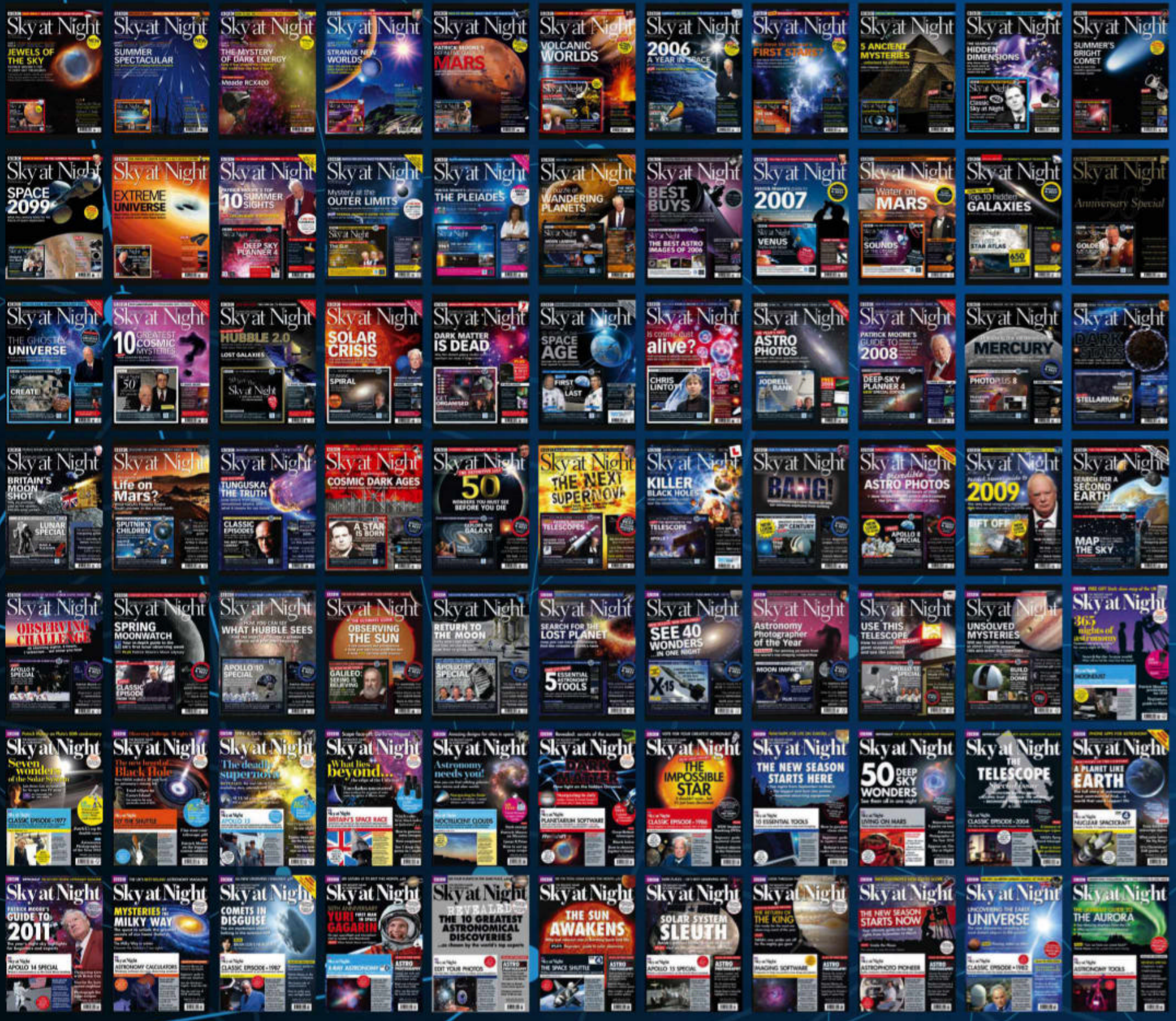
Then my advice is to join a society. Most towns have excellent societies; no qualifications are needed for membership and the benefits are enormous. By this time you will have found out what interests you particularly; in my case it happened to be the Moon. No doubt you will have different ideas, but in any case, your astronomical hobby will have been well and truly launched.

▸ A version of this article first appeared in issue 1 of the magazine, in June 2005, as the first of more than 80 monthly columns titled 'The Universe According to Patrick Moore'

Sky at Night Magazine

The editors' view

The magazine's past and present editors look back at how it started, creating 200 issues and their favourite moments



BBC Sky at Night MAGAZINE

ISSUE 200

Graham Southorn launched the magazine and was editor until issue 76, in September 2011

Graham regularly visited Patrick Moore's house in Selsey to keep him updated on the magazine

How did the idea for the magazine come about?
It began in 2002, when I was deputy editor of *Focus* (now *BBC Science Focus*), the popular science magazine. At that time it was covering a lot of interesting space and astronomy stories like Beagle 2 on its way to Mars, WMAP (Wilkinson Microwave Anisotropy Probe) finding clues to the Big Bang and the International Space Station (ISS) being built. So in 2003 I submitted a proposal for a space and astronomy magazine called 'Cosmos' and then, in 2004, when we came under the wing of BBC Magazines, my proposal was developed into *BBC Sky at Night Magazine*.

What were the key elements in your vision for the magazine?
I was keen for us to develop readers' skills: beginners would be able to progress with us and become more advanced astronomers, so there would be something in it for everybody. I was also sure readers wanted to know what was the best observing equipment to buy – telescopes, binoculars and accessories. We also created the 'Sky Guide' to be accessible with all levels of equipment. By late 2004 the proposal had the approval of the BBC Board. Then we took the idea to Patrick Moore to get his approval.

When did you first meet Patrick Moore?
I first met Patrick in January 2005. As I was pitching an idea for a magazine of the programme he'd been doing for 48 years, it made me a little nervous! I had prepared a long speech, but I only got a few sentences out before he said, "Yes, let's do it." I was dumbstruck – he'd agreed to it straight away. Later, Patrick revealed that he had wanted to do a magazine for *The Sky at Night* for years, but for one reason or another it had never happened. I didn't know how much he would want to do, or be able to do – he was already in his 80s then. But it turned out he wanted to do it all.

What was Patrick like to work with?
He was a joy to work with – always available on the phone and very helpful. We'd talk each month to establish the idea for his column. Then he'd fax through the copy and ring up to make sure we knew that he had sent it. I learned quickly that he had all the facts in his head. He didn't like mistakes and he didn't like any changes to his copy; but why would we want to when he wrote in such a conversational tone?

What events stand out for you on the magazine?
I think one of the highlights was the first Astronomy Photographer of the Year awards in 2009. It felt like a culmination of everything we were doing with 'Hotshots' and the start of something quite new. Then, early on, one of the team managed to get a picture of James Lovell and Fred Haise holding a copy of the magazine. To see the magazine being held by these two legendary astronauts was special.

▲ **Astronauts Fred Haise (left) and Jim Lovell holding a copy of *BBC Focus* and *BBC Sky at Night Magazine***

> ***"I was keen for us to develop readers' skills: beginners would be able to progress with us and become more advanced astronomers"***

Two other events stand out. One is the dedication of Yuri Gagarin's statue at the Royal Observatory Greenwich, when I got a copy of our *Man In Space* special issue signed by Gagarin's daughter, and the other is the celebration of *The Sky at Night*'s 50th anniversary at Patrick's house in 2007. There were all sorts of celebrities there: Bill Wyman, Terry Pratchett and Myleene Klass to name just a few.

What missions did you enjoy covering?
LOFAR (Low Frequency Array) struck me as incredible: a low-cost, flat-packed radio telescope that was able to collect huge amounts of data and then reassemble that data into an image. It showed how technology can really change astronomy. A recurring mission throughout my time on the magazine was Cassini. It just kept sending back incredible images from Saturn. One of the most memorable was its July 2013 image of Earth and the Moon below Saturn's rings.

▸ A version of this interview originally appeared in issue 100, in September 2013.

Chris Bramley has been the magazine's editor since issue 77, in October 2011

What changes have you introduced to the magazine?
Former editor Graham's vision for the magazine was very well put together, and much has remained in place. What we have done is refresh the magazine and in February 2019 we created new sections, including a regular one on astrophotography to reflect the explosion of interest in taking pictures of the night sky. We also modernised the look with new fonts and design elements, getting it ready for the new decade. One of the big changes I oversaw which many regular readers will remember, the move from the covermounted CD-ROM to providing the same content online, was done through necessity. As their use fell, the time came when there was no longer a production facility which could make the number of discs we needed.

"I especially enjoy the 'Interactive' section and hearing from readers, often with interesting and inspiring new takes on our hobby"

Do you have a favourite section of the magazine?
I love it all, but I especially enjoy the 'Interactive' section and hearing from readers, often with inspiring new takes on our hobby. I've also enjoyed creating practical covermounts that will be useful when readers are out observing the night sky, whether that's posters like the Moon Map and the Meteor Shower Guide, or the planisphere. I'm pleased that we recently created the Essential Stargazing Kit, which we're offering to new subscribers via social media at the moment. It's full of items that give newcomers a solid start to their stargazing journey.

What kind of astronomy do you enjoy?
When time allows I like to let photons of starlight meet my eyes directly, having a particular fondness for planets and star clusters. I have a 4-inch Newtonian on an EQ3-2 mount, but the instrument I use most is my 5-inch Maksutov-Cassegrain on a manual altaz mount, with some high-quality eyepieces and a finderscope with a wide field of view. It's a grab-and-go setup for those times when free moments align with clear skies, and which my kids can operate themselves (under supervision!) now they're a bit older.

What events have been the most memorable from your time on the magazine?
Working with the Astronomer Royal Martin Rees as Guest Editor on the 10th anniversary issue in 2015 was a real privilege – such breadth and depth of knowledge. He took a great interest and chose areas to cover which showed the direction that the science would progress in the six years after.

2015 also saw a total eclipse on 20 March, which from the mainland UK was the largest partial eclipse since 1999 and for years to come. We included a pair of free eclipse glasses with that month's issue and it was a sell-out: there were people driving to our offices to get a copy! Together with the Bristol Astronomy Society and the city's science museum, We The Curious, we held a free eclipse-observing event in central Bristol's Castle Park. Hundreds of people came and we gave out our eclipse glasses so they could watch safely. Just before maximum eclipse the cloudy skies cleared, and I still remember the silence that descended on the crowd as we all stared up in wonder at the crescent Sun – a magical shared experience!

Which missions have you most enjoyed covering?
I remain in awe of all the planetary missions that have taken place since issue 1, but two missions stand out. Firstly Rosetta and its Philae lander: how dramatic it was when the tiny spacecraft took two extended bounces off the surface of its cometary target before landing again! And the revelations revealed by the New Horizons mission in its flyby of Pluto were jaw dropping. It proved the value of such endeavours, and that we've only just begun to scratch the surface, even in a local area like the Solar System. When I think of New Horizons I recall the words of Jim Green, NASA's Director of Planetary Science: with it, he said "Humanity has completed the initial survey of our planetary system." That's quite an achievement, and a solid footing for more exploration in years to come.

▼ **Working closely with Chris, Astronomer Royal Martin Rees guest edited the magazine in 2015**

Astronomy for the masses: members of the public wear our covermounted eclipse glasses at the magazine's Bristol eclipse event in March 2015

Around 120 readers have received *BBC Sky at Night Magazine* through their letterbox every month since its launch in June 2005

The stars of Sky at Night Magazine

There are many readers who have been with us all the way, having been subscribers since issue one. Here we meet a few and hear about their enduring interest in the night sky

Our readers are a special bunch and we're always keen to hear from them with ideas to make *BBC Sky at Night Magazine* something for them. But for this celebratory 200th issue we got in touch with some of them – subscribers who have been with us from issue one. We found that an amazing 120 people have received every one of our 200 issues through the post. Here are five of these very special subscribers, who have kindly agreed to tell us a little about their associations with the night sky, astronomy, and with *BBC Sky at Night Magazine*. To all you stars of the magazine, thank you, and we salute you!

Name *Alan Hodgson*
Occupation *Writer on printing and imaging*
Location *Cheshire*
Age *64*
Favourite section *'First Light' equipment reviews*
Do you still keep any past issues? *I have them all at home and I am in the process of compiling an index of particularly interesting articles.*

Alan's background in photographic science informs his work and his astronomy, he says, and articles in *BBC Sky at Night Magazine* have too. "I worked in the photo industry on scientific applications and did various 'astro-facing' projects. Since issue one I've done some work for Cape Instruments, who made telescopes, and have been president of two different international imaging societies, so your articles have been referenced in other work.

"Our interests have evolved in similar directions. You've covered both current events and the evolution of imaging hardware and software," Alan explains.

Alan's project to rebuild Warren De La Rue's Moon camera under test in the garden...

...to check the focal length and condition of the 14-inch mirror

"In early editions I was an advertiser, but as I moved on I developed a wider interest. The series commemorating the anniversary of the Apollo space programme was excellent. Although not a binocular astronomer myself, I find that section useful for my photography. And I have to say that I've enjoyed it when you've printed my images!"

As a photographer, Alan says he uses DSLRs with standard camera lenses and gives talks on these, as well as imaging with assorted DSLRs and lenses. "My imaging is mainly done from Cheshire, but I also take them when I travel – most recently to Iceland, New Zealand and Galloway."

"I used to build technical cameras for a living and the bug has never left me, so I have various ongoing construction projects," he reveals. "My current interest is in following on from Galileo and showing what he saw. I'm doing a series on Venus but I want to move over to lunar imaging. I have a long-term project (pictured) to rebuild Warren De La Rue's Moon camera from 1854."

Growing up under urban skies, Alan says he learnt a few constellations from these. "As a child, my parents bought me a very shaky small refractor and it went from there, with a few Patrick Moore books." ▸

PETER TITMUSS/ALAMY STOCK PHOTO, ALAN HODGSON X 3

Name *Jayne Waters*
Occupation *IT business consultant*
Location *South Wales*
Age *53*
Favourite section *'Bulletin'*
Do you still keep any past issues? *Yes, all of them, mostly in binders; plus the CD-ROMs they used to come with.*

Jayne began reading *BBC Sky at Night Magazine* when it first came out, because most of the available magazines back then were American and *The Sky at Night* TV programme was something she'd grown up with. "The magazine has always had a good selection of articles that range from practical guidance on observing to more theoretical articles," she says. "These support the astrophysics and cosmology which sit behind the astronomical objects we observe. It's that combination of practical 'how to' and insight into the science that I've always enjoyed."

A lunar occultation of Saturn, like this on 1 December 2001, captured Jayne's imagination

SIMULATION

As a child, Jayne says she was fascinated by the night sky and never grew out of it, and she has been lucky to have always lived in areas with reasonably dark skies. Her fascination later led to a degree with the Open University, which she focused around astrophysics and cosmology. "It rekindled my interest in astronomy again," she remembers.

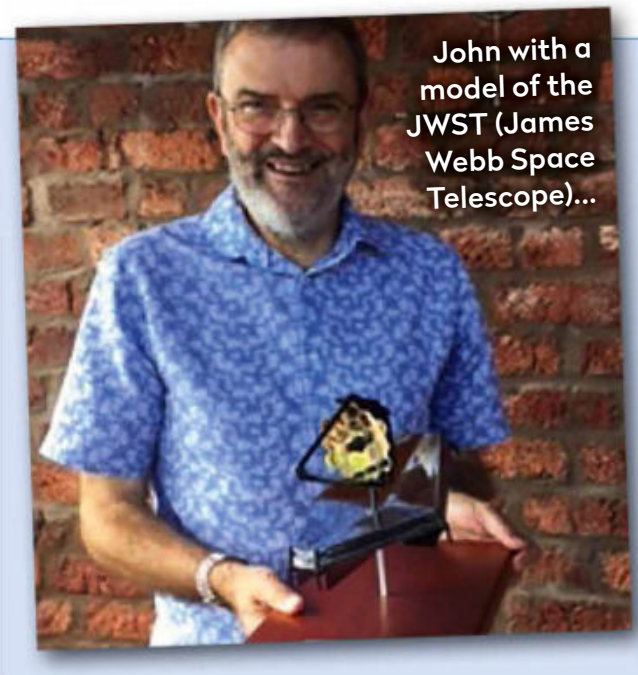
"However, the science and observation are two different things for me. I'm fascinated by the science, and the underlying theories of our Universe and the objects and phenomena that exist within it," she says, "But the act of observing the night sky is much more of an emotional experience – the aesthetic beauty is breathtaking."

Today Jayne has a Sky-Watcher ED120 refractor, "...and an ancient Meade LX200," she says. "These days, most of my observing is unstructured and done [without them]." A few targets were favourites for telescopic observation, she says. "Globular clusters – they are amazing objects both from a visual and scientific perspective. And I remember seeing a lunar occultation of Saturn at about 3:30 in the morning many years ago – it made the hairs on the back of my neck stand up. It was an amazing example of the dynamic, three-dimensionality of our Solar System."

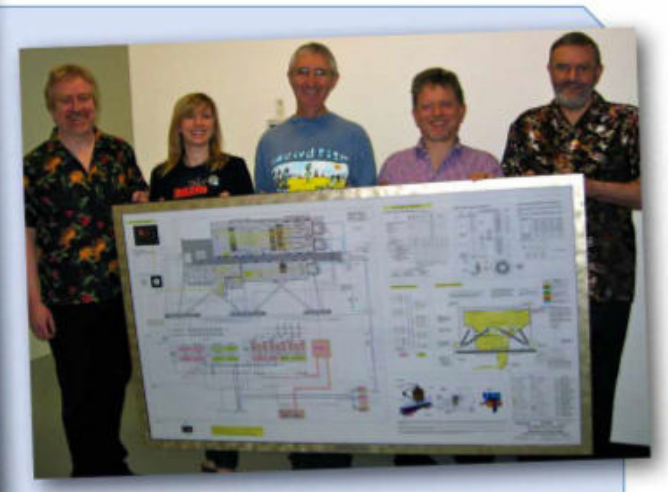
Name *John Thatcher*
Occupation *Engineer and space industry project manager (retired)*
Location *Shrewsbury*
Age *71*
Favourite sections *Telescope advice and tips, 'First Light' equipment reviews*
Do you still keep any past issues? *I have the first 55 issues in binders, and the 100th issue. I keep the last few years' worth and recycle the oldest on a rolling basis.*

John nearly didn't make it past the first few months of his subscription: a busy work and family life meant the first few issues were put to one side to read later. "After four or five issues formed a little pile, I made a determined effort to catch up, and found the mix of articles and information a good match for me," he recalls. "Since then I've not stopped reading the magazine every month."

He'd been a regular watcher of *The Sky at Night* and had met Patrick Moore several times, so when the magazine was launched it seemed a good opportunity to find out more. "The history of orbital spaceflight and planetary exploration has occured during my lifetime and I was gripped by the Space Race in the 1960s," he says. "My interest in astronomy followed on from that."



John with a model of the JWST (James Webb Space Telescope)...



▲ ... and (right) with the team at Astrium who worked on JWST's MIRI instrument

This led to a 30-year career in the space industry, working on a number of scientific spacecraft. "For the last 10 years of my career I was the European Consortium Project Manager for the Mid-Infrared Instrument (MIRI) on the James Webb Space Telescope and worked with many professional astronomers all around Europe and the USA.

Now retired, John observes with various binoculars up to 15x70 size and a Sky-Watcher 200mm reflector on an EQ5 mount, as well as the naked eye. He reveals: "I made a decision not to get into astrophotography, having been advised it was a good way to lose hours of your life and spend a lot money! But I enjoy seeing what others can do."

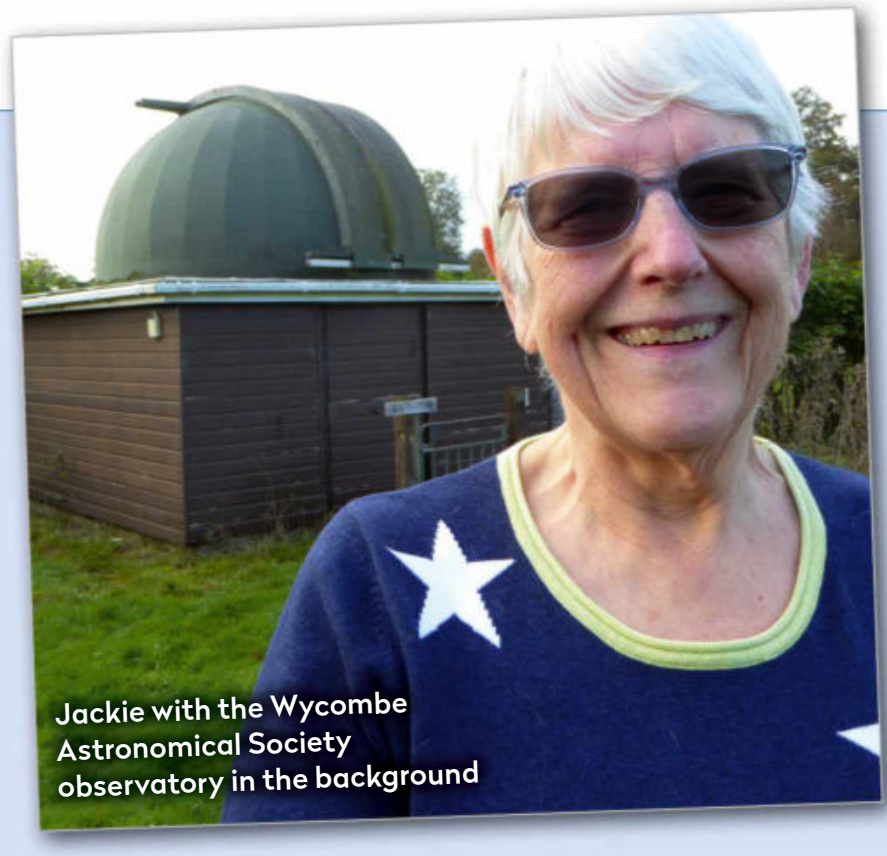
Being a member of Shropshire AS and an honorary member of Bedford AS allows him to do just that: "Their observers take some extremely good images," he says. "We do lots of public outreach and I'm a big believer in encouraging people to look at what is free-to-see right above their heads."

PETE LAWRENCE, JOHNTHATCHER X 2, JACKIE HARRIS X 2, STEWART CHAMBERS X 2

Name *Jackie Harris*
Occupation *Retired*
Location *Beaconsfield, Buckinghamshire*
Age *78*
Favourite section *'The Sky Guide', especially 'The Planets' section*
Do you still keep any past issues? *Originally I did, but I donated them to my Society library when I moved house. Now I only keep the past few months.*

Jackie was always curious and interested in the sky above, studying applied physics after leaving school. In 2003 she followed her interest, she says, and hasn't looked back. "I got my first telescope then and joined the local Wycombe Astronomical Society, and when I saw that *BBC Sky at Night Magazine* was first published I started reading it."

She became the Secretary of Wycombe Astronomical Society, arranging its outreach events for 15 years, and later became a Friend of the Royal Astronomical Society. "Until the pandemic I went up to London for a couple of [RAS] lectures a month and attended two more at the Society. These have more recently taken place on Zoom, allowing our interest to be continued."



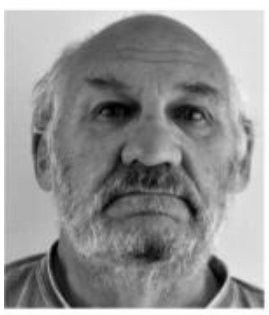
Jackie with the Wycombe Astronomical Society observatory in the background

As for practical observing, Jackie says she is very interested in the planets and the Moon in particular, and also deep-sky objects. "Sadly I live in quite a bright area so I didn't get into astrophotography," she says. "Luckily we have a large scope at our Society observatory for use by members, and we hope to be opening it again very soon for practical astronomy following the COVID shutdown.

"Now I'm older I do less observing, as I found it difficult to carry my 8-inch Celestron telescope," she says, "But I have now passed that onto a friend's family member and have an 80mm William Optics scope on an iOptron mount, and also a solar scope.

"I've enjoyed all the magazine articles and found the guidance on what to look for each month extremely helpful for my observing," she says. "I have kept reading the magazine because I have learnt so much from it over the years."

Name *Stewart Chambers*
Occupation *Science teacher (retired)*
Location *Isle of Wight*
Age *66*
Favourite sections *'Bulletin', 'Cutting Edge' and 'Moonwatch'*
Do you still keep any past issues? *I used to keep them but now I only keep a year's worth. I pass on the previous year's issues to local schools through the astronomical society I belong to.*



"Like many people of my generation, it was the Apollo missions that sparked my interest in astronomy," says Stewart. "That and watching Patrick Moore on *The Sky at Night*." Many years later he was left some money that enabled him to purchase a telescope, he says. "The first views of the surface of the Moon in detail, the rings of Saturn and the dance of the moons of Jupiter had me hooked."

Stewart started reading *BBC Sky at Night Magazine* because it was endorsed by Patrick Moore and was linked to the television programme, he recalls. "I also liked the CD-ROM idea, containing bonus material and archive TV programmes.

▲ Based on our 'First Light' review, Stewart now uses a Daystar Solar Scout telescope for observing the Sun

▲ Pete has 'dabbled' in astrophotography, taking this wonderful Snow Moon image with a DSLR and 300mm telephoto lens

"I've kept on reading the magazine to keep up to date with the recent developments in astronomy and to see what the monthly observing highlights are," Stewart says. "I also like reading the features. It has been interesting to read the articles reviewing the outcomes of previous and continuing missions exploring the Solar System, such as the Apollo missions and those to the outer planets."

With an Orion Optics SX250 10-inch Newtonian reflector mounted on a Sky-Watcher HEQ5 Pro mount, Stewart says he does observe the night sky but not always on a regular basis. "I tend to observe the Moon and planets but have not yet ventured to view deep-sky objects."

"Based on a review in *BBC Sky at Night Magazine*, ('First Light', April 2019) I've purchased a solar telescope to observe the Sun," he says. "My solar scope is a Daystar Solar Scout SS60-DS, which I mount on a Star Adventurer tracking mount placed on my camera tripod. Astrophotography is an area that I have dabbled in but only with my DSLR."

BBC

Sky at Night MAGAZINE

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BBC Sky at Night MAGAZINE

200 issues of OBSERVING

To mark our 200th issue, **Pete Lawrence** and **Paul Abel** sat down to discuss some of the highlights to have graced the night skies since the magazine's launch

POI: SOLE SALLES/M-GUCCI/ISTOCK/GETTY IMAGES, PETE LAWRENCE X 2, MALCOLM PARK SCIENCES/ALAMY STOCK PHOTO

"I remember observing Comet 17P/Holmes with Patrick Moore and he said, "It's just peculiar." He was right, it was – it looked like a dinner plate!"

Pete: *BBC Sky at Night Magazine* started in the middle of 2005, quite a while ago in terms of astronomy. The more you think about it, the more events you realise there have been since that first issue.

Paul: I'd like to kick off with something recent: Comet NEOWISE, which was a spectacular naked-eye object seen during summer 2020. This was one of the best naked-eye comets since Hale-Bopp for UK skies because it was really well placed. It coincided with lockdown so we were all at home and the weather was really good. We had an unprecedented long spell of clear nights and I think NEOWISE was as good as Hale-Bopp in the 1990s. It was that long since I'd seen a bright, naked-eye comet. I know we had McNaught – that was a good comet. You saw the tail of that from Selsey, Pete, but it didn't actually climb high up. NEOWISE was the first one we've had for a while.

Pete: Yes, C/2006 P1 McNaught, that is going back a bit – I think that was 2007. That was impressive; I took a good photograph of it during daylight. It went into a spectacular outburst when it passed into the southern skies and the tail exhibited those striations you get, called synchronic bands. Judging by some of the stars I could see in the wonderful pictures taken from the Southern Hemisphere, I figured out that I might also be able see some of the bands from the Northern Hemisphere. I went down to the beach at Selsey [in West Sussex], where I lived, and was able to pick some of them up. But the comet that really stands out for me is one

Pete caught C/2006 P1 McNaught from Selsey during daylight

that had an outburst at the end of 2007 into 2008, and that is Comet 17P/Holmes.

Paul: Yes, it was quite greenish and it looked rather like a fried egg!

Pete: I remember observing that with Patrick Moore and he said, "It's just peculiar." He was right, it was – it looked like a dinner plate!

Paul: It dimmed quite rapidly. The larger the comet got, the fainter it became. So you had a situation where it was really quite a large diameter in the sky, but it was almost impossible to pick up visually. Although long time-scale pictures brought it out well.

Pete: Yes, indeed. Actually, people often ask me about the best things I've ever seen in the night sky and it's difficult to say one particular thing. But one thing does stand out; do you recall the time we went to Kielder Observatory in Northumberland?

Paul: Oh, that was so cold. It was so cold.

Pete: We went there to see an asteroid that was doing a close pass of Earth. It was quite windy and there were very dark skies. I had my binoculars and managed to locate the area where it was. The asteroid was called 2012 DA14 and that was 15 February 2013. I remember being able to spot it because it moved against the star field. It really struck me that I'd never really seen a natural object other ▸

Comet 17P/Holmes baffled observers by becoming fainter as it grew larger

▸ than a meteor or the aurora physically moving against the stars. It stood out and it really stayed with me.

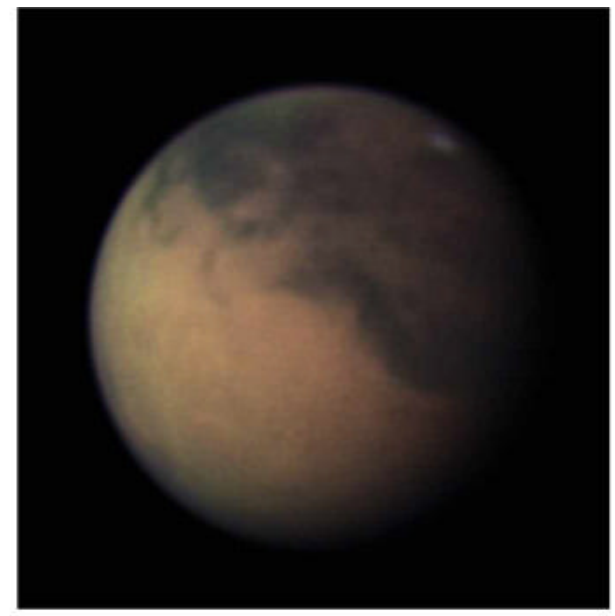
Paul: I remember that. We were filming *The Sky at Night* and you directed us how to find it. Jon Culshaw was there and I think all three of us did manage to get it in binoculars at one point, but I lost it. It was passing near Ursa Major and I remember you saying, "Quick now, it's just near the Plough." So I looked and I found it. Then somebody asked me something and I turned away momentarily and lost it! I couldn't recover it after that, but what surprised me was the speed at which it was moving because I thought it was going to be much slower in the sky, but it turned out to be quite a speedy object.

Pete: Yes, it was indeed.

Paul: Do you remember driving up there? I don't drive. Patrick thought the idea of me behind the wheel of a car was far too terrifying, so we had a gentlemen's agreement that I'd never learn to drive. Pete, you always drive and I think it's fair to say that you're quite dependent on the satnav.

Pete: Oh yes.

▲ Paul's sketch of Mars, made during the 2020 opposition, shows the planet's polar cap and white cloud patterns



▲ Armed with his trusty 14-inch Schmidt–Cassegrain telescope Pete took this image of Mars during the 2020 opposition period

Paul: When we got up to Kielder we were looking for the filming location and it wasn't in the satnav. Do you remember we asked that chap in the pub and he gave directions that were really good, except he missed a right turn by the river and a left going up the hill. It's the first time I've ever seen you really get cross. We'd driven down to the wilderness and I said, "Pete, I don't think this is right." And you just said, "I can tell this isn't right, you idiot!" I deserved that, but it was quite amusing.

Pete: I say that to you all the time!

Paul: And you're still dependent on the satnav. Anyway, my next choice would be the Mars opposition in 2020. We've both seen a lot of Mars oppositions, but this was special for me because it was the first year I had my own large telescope. You know how it is: you spend a long time with a 6- to 8-inch telescope, but after about a decade you're ready to move on. I have access to the University of Leicester telescope, but it's a big turning point in your observing career when you have your own big telescope. I'd just got a 12-inch Newtonian and we had a run of clear nights towards opposition. I had some of the most fantastic views of Mars I've had in my life. I was able to use powers of 600x magnification and I made 78 colour drawings of Mars. I also made two maps and charted the dust storm that erupted. It's the most intense period of work I've ever done on the Red Planet because I had access to a big telescope.

Pete: Once you've got a good run, it draws you in. I remember one opposition when I got into a similar state. I could set up the telescope quickly outside and off I'd go. Some nights you had crystal clear, steady seeing, but I had an issue with my imaging chip because there was a mite living on it.

Paul: That could only happen to you!

Pete: The creature obviously liked to bathe in the light from Mars because every time I put the telescope on the planet, it would crawl across the chip and sit right in the middle of the image. I'd have to continually move the image around on the sensor to try and avoid this creature getting in the way!

But talking of the planets takes me right back to 2007, in the magazine's early years, because there were a number of interesting lunar occultations at that time.

PAUL ABEL, PETE LAWRENCE X 5

"The creature obviously liked to bathe in the light from Mars because every time I put the telescope on the planet, it would crawl across the chip and sit right in the middle of the image"

2007 saw two significant interactions between Saturn and Earth's Moon

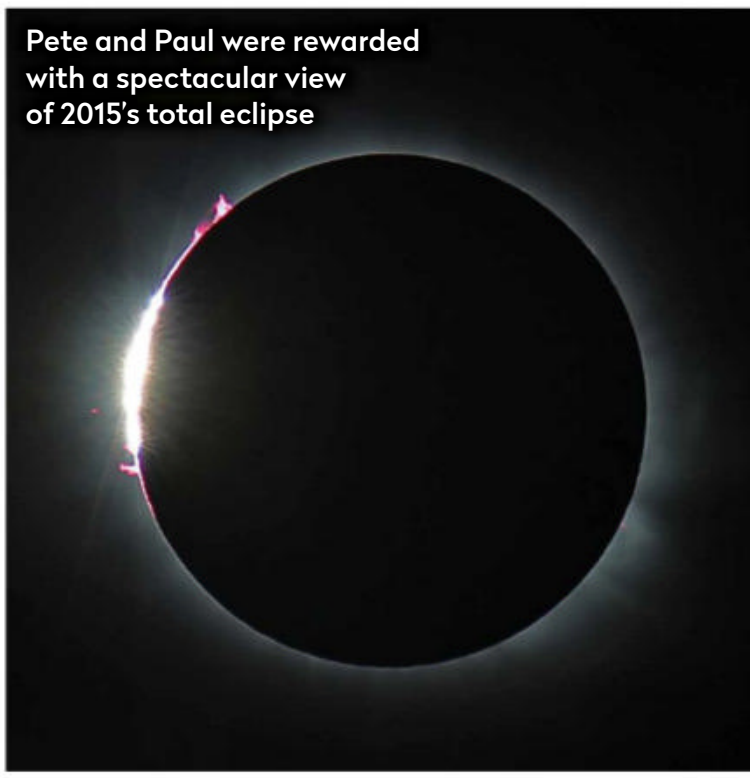
On 2 March 2007, Saturn was grazed by the Moon. From my location, only part of the planet was actually clipped by the edge of the Moon, which led to some nice images. On 22 May that same year, Saturn was properly occulted and then on 18 June – again in 2007 – Venus was occulted by the Moon. We had a really good run of planets disappearing behind the Moon's disc, which hasn't really happened since. Actually, something to look forward to at the end of 2022 will be two occultations of Uranus and an occultation of Mars.

Paul: I remember those occultations because I was quite an active observer in the late '90s. Then, in 1999 I went to university and you know how it is when you go to college, you kind of lose touch with things. I lost touch with amateur astronomy and it wasn't until my PhD in 2005 that I came back to it, when *BBC Sky at Night Magazine* had just started. I picked up this new magazine and that's when I got going again. Not long after that we had all those astronomical events. I don't think we met until 2007, though.

Pete: It seems like a lot longer.

Paul: Moving on, my next choice includes the pair of us. It was the trip on the *Boudicca* with you, me and Jon Culshaw to see the total eclipse in 2015 near the Faroe Islands. This was the first time I had ever seen a total eclipse of the Sun and it nearly didn't happen. Do you remember the weather? How touch and go it was?

Paul and Pete (centre) set up for the total eclipse aboard the *Boudicca* in 2015



Pete and Paul were rewarded with a spectacular view of 2015's total eclipse

Pete: I took a bit of a responsibility there because I had a good rapport with the captain, and the first thing he said to me was, "Before we do anything else, we just agree there is no blame, okay?" So he obviously knew what the Norwegian Sea was like in March! The night before the eclipse I saw a band of weather expanding and the location we were headed for would have been underneath it. I emailed him to say we needed to go further north and, next morning, it was like he'd put his foot on the accelerator. The ship was just pounding through the waves. I can remember getting up and there was thick snow coming down on the deck of the ship and people walking past going, "Don't worry, Pete, it's not your fault." I thought, "But it hasn't even happened yet!" As we got closer, the clouds began again to break up and we got to see the whole of totality.

Paul: Do you remember there were a couple of other ships that stayed behind? They didn't move and they were clouded out. We were so lucky, we were among the few people to see it. I can still picture it in my mind's eye – it's almost an absurd image of a brilliant black circle. It was only 10am in the morning and afterwards we had champagne and celebrated.

Pete: Absolutely. We've seen a lot of eclipses over the 200 issues of the ▸

The lunar eclipse of 2015 saw a beautiful display by Earth's natural satellite

▸ magazine, but my first proper one wasn't a total eclipse, it was an annular eclipse in Madrid that I saw while filming with *The Sky at Night* on 3 October 2005.

We had decided to set ourselves up in Parque Tierno Galván, which has a planetarium in it, and we picked our spot at some ridiculous hour in the morning before the Sun had come up. We got to see a lovely annular eclipse and then the next year, on 29 March 2006, I took a group of about 1,600 people to Turkey, where we were treated to the beautiful sight of a spectacular total eclipse – my first proper view of a total eclipse of the Sun. I can still remember that feeling of looking up at the eclipse and feeling the cold of the Moon in front of the Sun. I couldn't help but think, "Crikey, we're pretty insignificant on this planet."

We've had a number of lunar eclipses too. Two recent ones stand out pretty well for me. I remember one on 28 September 2015, which we saw from a mutual friend's meadow in Ham, just outside Selsey. I decided to take quite a lot of equipment to get multiple shots and I drove us over there, dropped all the kit off and then went back home and picked up another car load of kit.

Paul: I should point out that all I had was a notebook and a pencil! You're the one that filled the car up. Do you remember how low the car was?

Pete: Then we had another lunar eclipse on 21 January 2019. I picked you up and we both came back to Selsey and it was beautifully clear.

Paul: It was also really cold! As I recall, the colour was quite strong: there was a good orange tint to the Moon. It was also quite a dark eclipse. They always vary in terms of how orange or how dark the Moon goes during totality. We made lots of cups of tea because it was so cold.

Pete: Not as cold as the one I did for *The Sky at Night* on Selsey beach during the 2010 winter solstice.

Paul: I remember you went down and did it on your own and you were freezing to death.

Pete: The sea was up on the sea wall and it froze. It was rock hard. I don't think I've ever been so cold in my life.

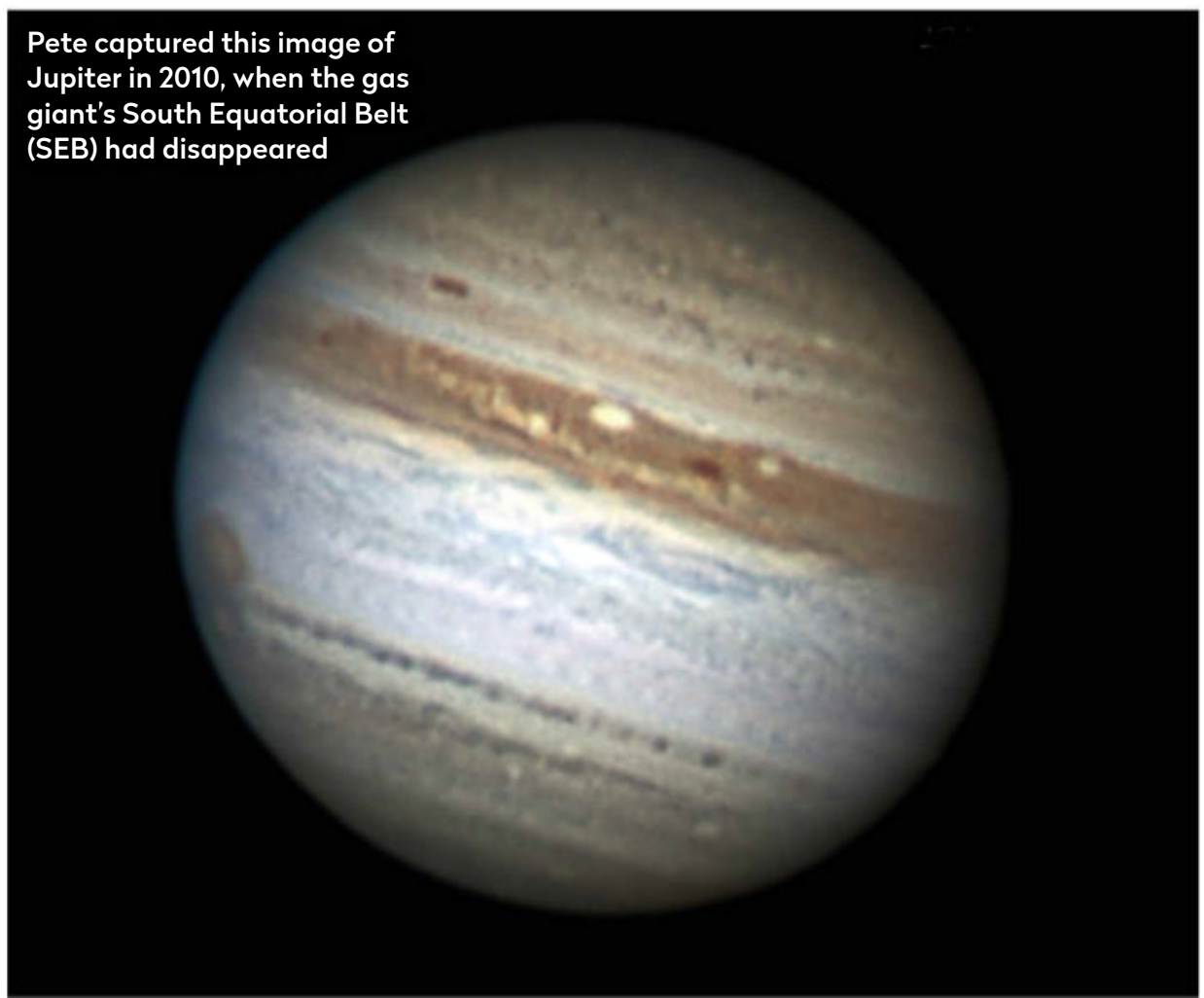
Paul: Another event that we both saw was that very unusual storm on Saturn in December 2010. Do you remember that?

Pete: Was that the Dragon Storm?

Paul: Yes, the Dragon Storm. Saturn has these big, bright oval storms. And what normally happens is about every 30 years a bright oval erupts in Saturn's equatorial zone and then goes back to normal. But this one started off in Saturn's north temperate zone. It was first detected on 5 December. The Cassini spacecraft was in orbit around Saturn and managed to record the storm breaking out, and the rapid thunder and lightning. It extended around the north temperate zone and became almost like a comet. Typically, it was quite cloudy in Leicester that year, so my first observation of it wasn't until later, about 12 May, with my 8-inch reflector. I put a blue filter on and it was very unusual. It stands out in my mind as quite an out of the ordinary event on Saturn.

Pete: That reminds me, was it 2010 when Jupiter lost one of its main belts, the South Equatorial Belt (SEB)? It just suddenly disappeared, didn't it?

Paul: That's right. Jupiter undergoes this phenomena called an SEB fading



Pete captured this image of Jupiter in 2010, when the gas giant's South Equatorial Belt (SEB) had disappeared

PETE LAWRENCE X 3, JIM WALLING / ALAMY STOCK PHOTO

"I remember that 2012 transit of Venus because I stayed behind with Patrick and we were among the very few observers who actually viewed it from the UK"

and revival, when the South Equatorial Belt fades away and the Great Red Spot becomes dark and intense. Sometimes, a year or more later, you get eruptions breaking out where the South Equatorial Belt used to be, then they join up and the belt reforms. It's most mysterious.

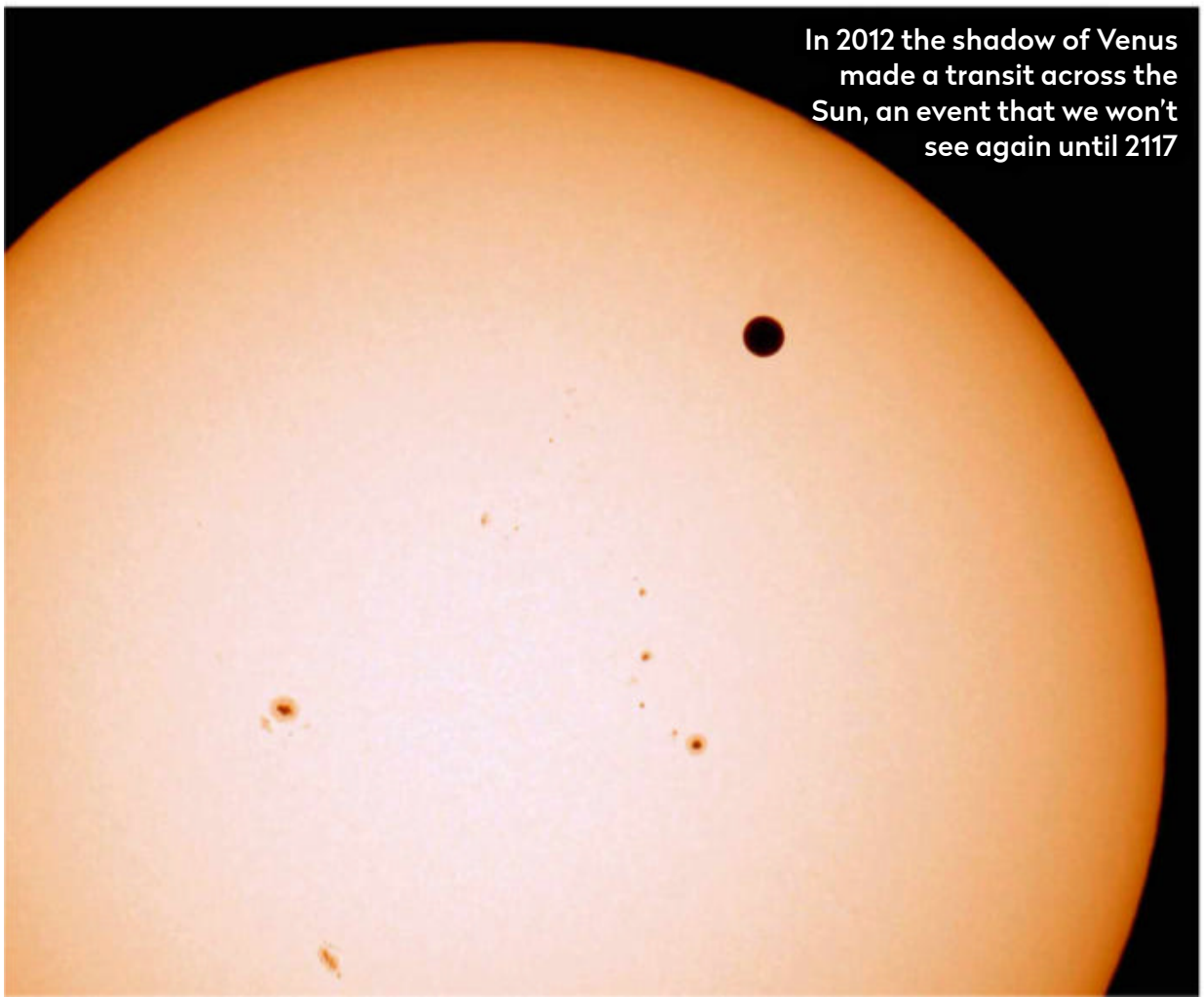
Pete: I also wanted to bring up transits. We had a transit of Venus back in 2004, but we also had one in 2012 on 6 June. That was the time when *The Sky at Night* went to Svalbard in the upper reaches of Norway, to try and get a view of it, since it would be the last transit of Venus we will see in our lifetimes. On the day before it was an absolutely beautiful clear sky and I thought, "Yeah, we're going to get this, no problem at all." I managed to get my telescope set up outside the accommodation block on very rough gravel. I remember because I was kneeling down on it with a cloth over my head. We did manage to get a lovely view of the transit, even though it completely clouded over the next day.

Paul: I remember that 2012 transit of Venus because I stayed behind with Patrick Moore and we were among very few observers who actually viewed it from the UK. Jon Culshaw, myself and a number of others went down to Selsey beach with Patrick, pushing him in his chair, and it was around four or five in the morning. Just at the right moment we had a big gap in the clouds and we were able to see the transit. Patrick observed the transit of Venus through the telescope and I think that must have been the last astronomical event he ever saw.

We were so lucky to have been able to see it because not long afterwards the sky clouded over again and we decamped. I think a few people were quite surprised to be offered champagne and cake with Patrick around six in the morning, but it felt like quite an achievement.

Pete: Looking back, it's been a pretty spectacular 200 issues' worth of events. I'm looking forward to what the next 200 issues will bring.

Paul: Yes, who knows what we'll see. There are all sorts of fascinating observational things to come. Maybe in one of the next 200 issues we'll have news of a discovery of life on Mars or Europa. Anything could happen!



In 2012 the shadow of Venus made a transit across the Sun, an event that we won't see again until 2117

MORE ONLINE

Listen to the full recording of Pete and Paul's stargazing highlights chat (see page 5 for details)

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Paul G Abel is the director of the British Astronomical Association's Mercury and Venus section, and a theoretical physicist

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

JANUARY 2022

CATCH THE QUADRANTIDS

Observe the meteor shower as it reaches peak activity

MEETING OF PLANETS

Mercury and Saturn make a compact triangle with the crescent Moon

WATCH THE MOON COVER A STAR

View the lunar occultation of double star Zubenelgenubi

BABAK TAFRESHI/SCIENCE PHOTO LIBRARY

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Comet C/2019 L3 Atlas reaches perihelion
- The star Sirius passes its highest position
- Lunar crater Nasireddin is near the terminator

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

JANUARY HIGHLIGHTS

Your guide to the night sky this month

Saturday ▶ 1

Mag. +1.5 Mars lies 5.5° northeast of mag. +1.0 Antares (Alpha (α) Scorpii), both objects rising 100 minutes before the Sun above the southeast horizon. A delicate 2%-lit waning crescent Moon sits 8° east-southeast of Mars.

Sunday 2

Lunar perigee, the point where the Moon is closest to Earth, occurred at 23:00 UT on 1 January, making today's Moon a perigee new Moon, also known as a supermoon. It doesn't get as much coverage as a perigee full Moon since you can't see it.

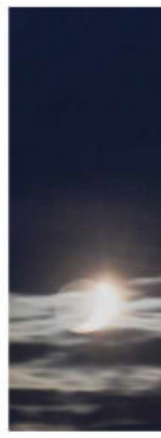
Tuesday 4

Mag. –0.6 Mercury, +0.9 Saturn and a 5%-lit waxing crescent Moon form a compact triangle low in the southwest after sunset. The trio are followed by mag. –2.0 Jupiter.

Earth is at perihelion, the closest point in its orbit to the Sun.

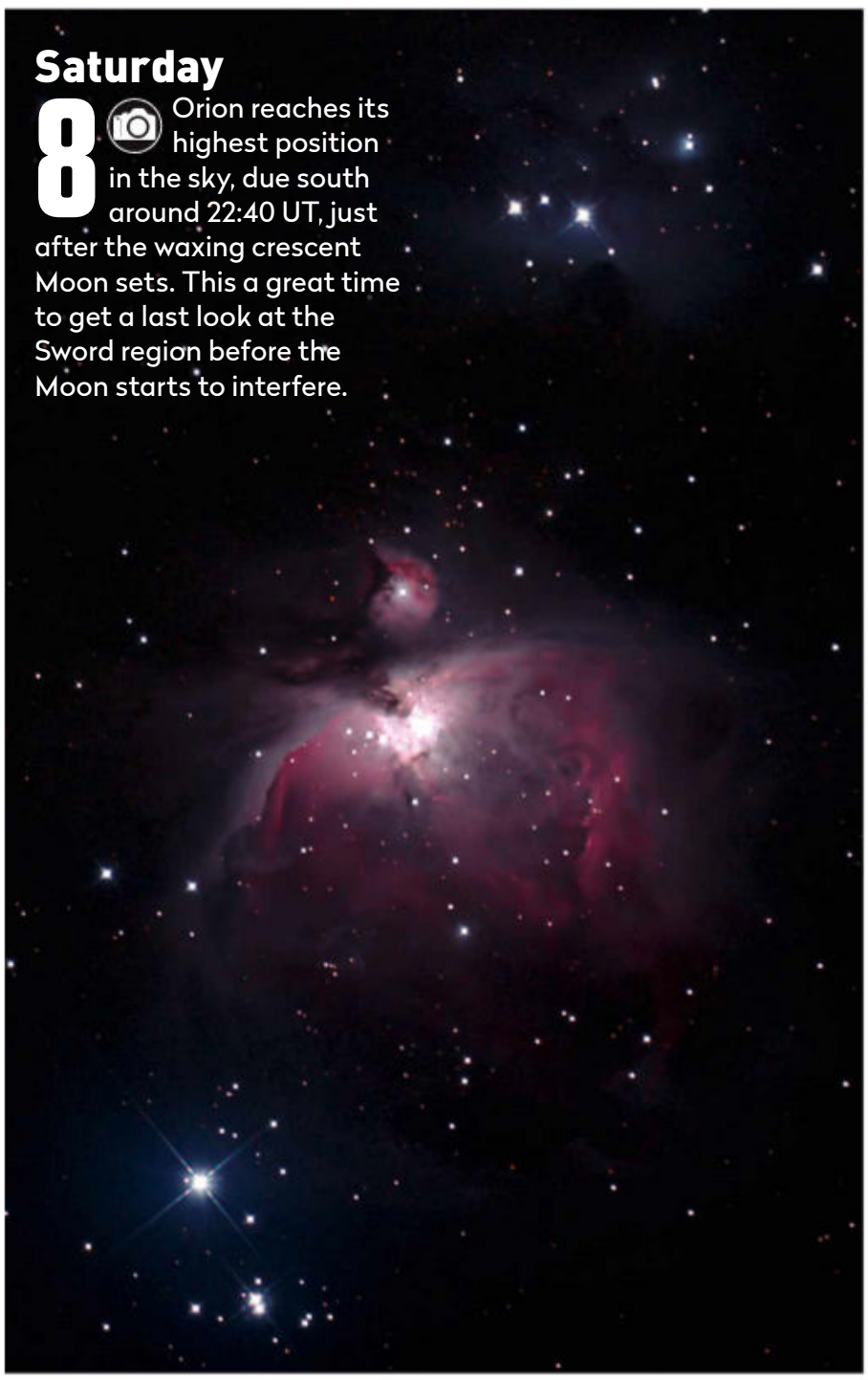
Wednesday ▶ 5

Catch this evening's 12%-lit waxing crescent Moon as it sits 7.5° southwest of mag. –2.0 Jupiter.



Saturday 8

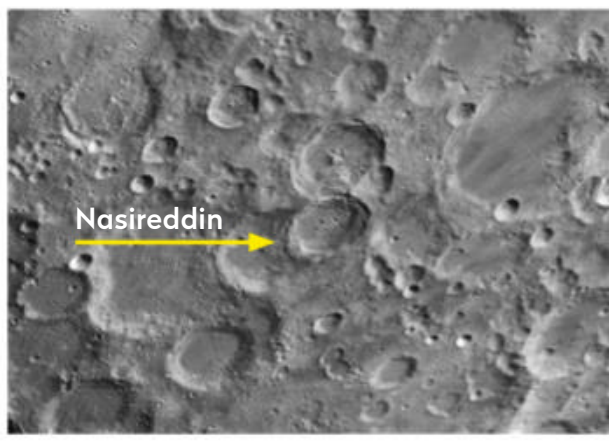
Orion reaches its highest position in the sky, due south around 22:40 UT, just after the waxing crescent Moon sets. This a great time to get a last look at the Sword region before the Moon starts to interfere.



PETE LAWRENCE X 7

Monday ▶ 10

January's 'Moonwatch', the crater Nasireddin, can be seen near the terminator this evening.



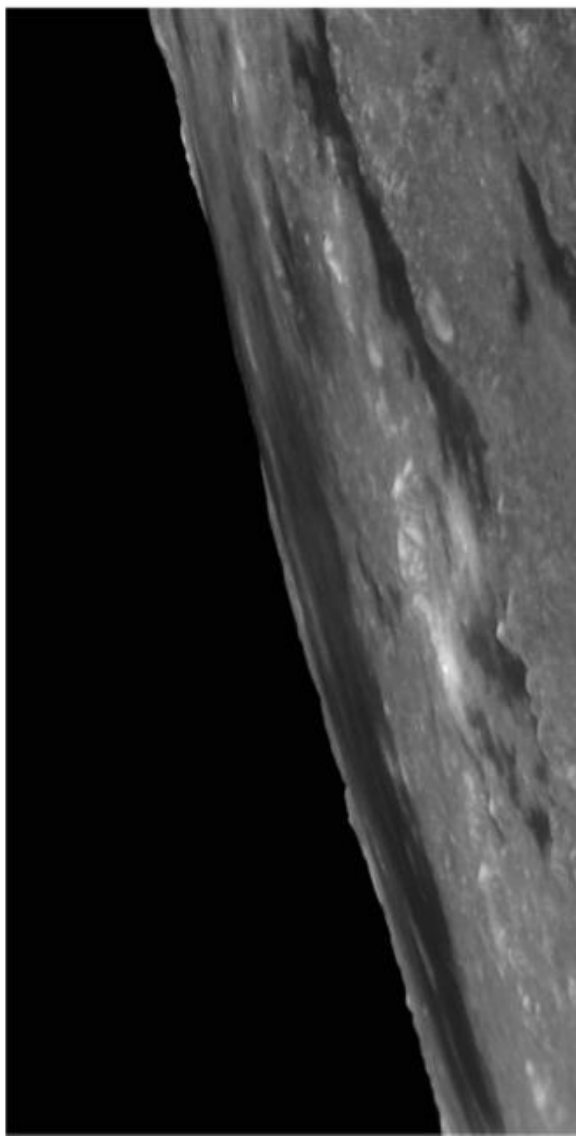
Comet C/2019 L3 Atlas reaches perihelion today and appears at its brightest, around mag. +9.7. See page 47.

Friday 14

Mag. +0.6 Mercury and mag. +0.9 Saturn appear 3.6° apart in the early evening sky. The pair should be visible 30 minutes after sunset. They remain above the horizon for around 90 minutes after sunset.

Friday 28

On this morning's 21%-lit waning crescent Moon, the bright crater Aristarchus is near the terminator about two-thirds of the way up. Aristarchus (40km) is the brightest feature on the Moon's Earth-facing side.



Monday ▶ 3

This evening into tomorrow morning is the best opportunity to watch the peak of the Quadrantid meteor shower. With new Moon on 2 January, this year's peak is particularly favourable, see page 46.

Thursday 6

This evening, the now 20%-lit waxing crescent Moon sits 9.3° east-southeast of Jupiter.

Friday 7

Mercury reaches greatest eastern elongation today, appearing separated from the Sun by 19.2° in the evening sky. The mag. –0.5 planet sets approximately 100 minutes after the Sun.

Wednesday ▶ 12

An evening view of the Moon through binoculars reveals an arc of light extending into darkness. The arc represents the Jura mountain peaks illuminated by the lunar dawn, a clair-obscur effect known as the 'Jewelled Handle'.

Thursday 13

Minor planet 7 Iris reaches opposition today. Shining at mag. +7.7, Iris can be located roughly midway between Pollux (Beta (β) Geminorum) and Procyon (Alpha (α) Canis Minoris).

◀ Saturday 22

Look at the southwest limb of this morning's 83%-lit waning gibbous Moon and you may be able to make out the dark lava patches of Mare Orientale and the lunar lakes that surround it.

Wednesday 26

This morning's 42%-lit waning crescent Moon occults the double star Zubenelgenubi (Alpha-1 (α^1) Librae and Alpha-2 (α^2) Librae) around 05:23 UT (time correct for the centre of the UK). See page 47 for more.

Thursday 27

As Sirius (Alpha (α) Canis Majoris) passes its highest position, due south around 22:30 UT, look 4° south of the star using binoculars to locate the beautiful open cluster M41.

Saturday 29

Mag. +1.4 Mars lies 5.4° to the northeast of this morning's 12%-lit waning crescent Moon. Catch them together with mag. –4.5 Venus 10.5° to the northeast of Mars, 80 minutes before sunrise low above the southeast horizon.

Family stargazing

Orion is prominent, making this an excellent time to introduce the Hunter to young observers. Point out the three Belt stars in the middle of the main pattern. Identify the faint line of the Sword, hanging below the Belt. At the bottom of the main pattern are Saiph (left) and Rigel (right). Compare the colour of Rigel with orange Betelgeuse in the upper-left corner. Betelgeuse is old and running out of fuel; it is believed to be a thousand times larger than our Sun. In the upper-right corner is Bellatrix and in between and higher, is a triangle representing Orion's head. **bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

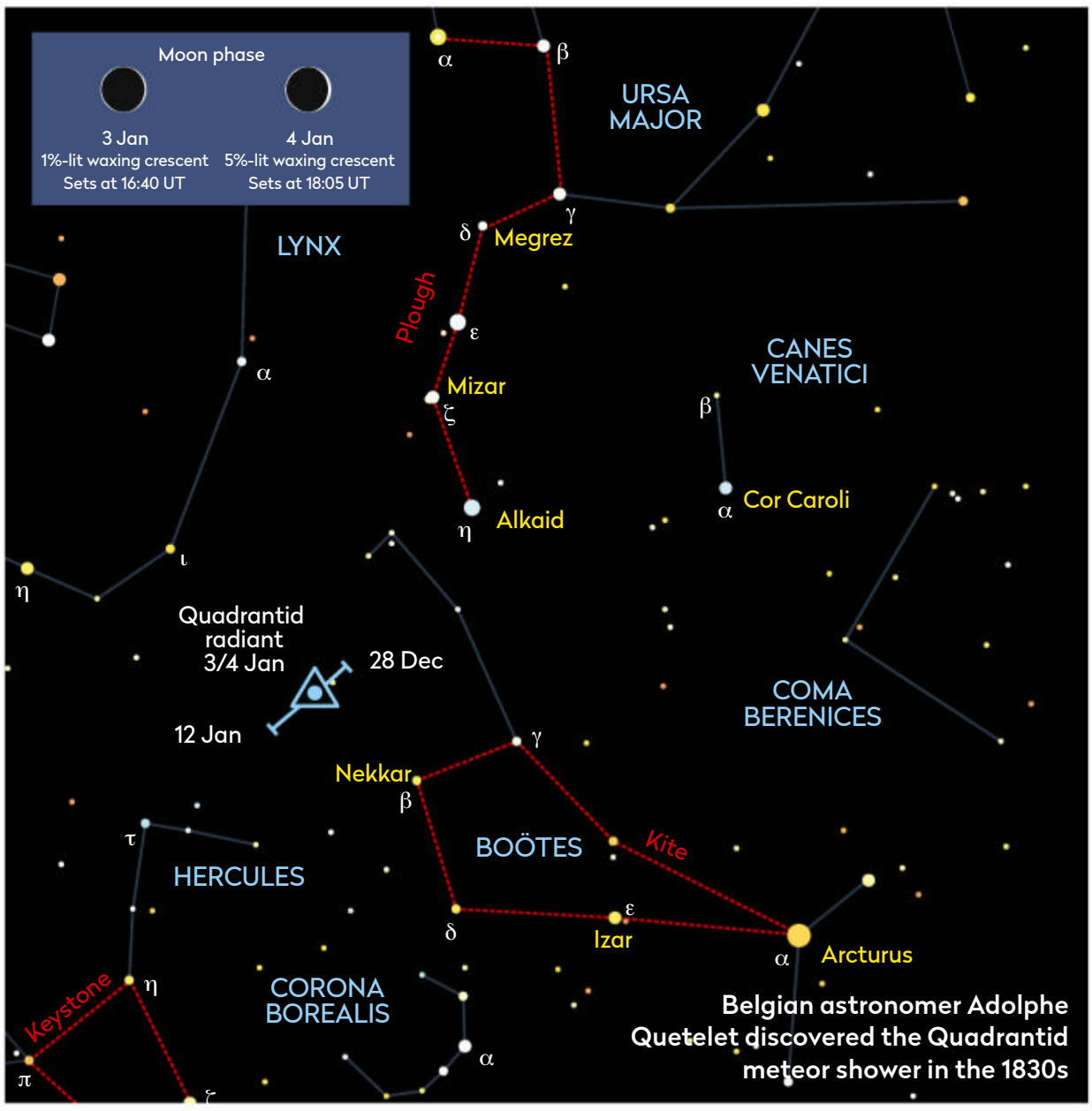
THE BIG THREE

The top sights to observe or image this month

DON'T MISS

QUADRANTID METEORS

BEST TIME TO SEE: 3/4 January



The Quadrantid meteor shower heralds the start of the New Year's meteor activity. It is a high-rate shower with a typical peak ZHR (zenithal hourly rate) of 120 meteors per hour, which has been known to vary between 60–200 meteors per hour. Despite the cold, if the sky is clear on the evening of the 3rd, it is well worth putting in the effort as the Quadrantid meteor shower can deliver a fantastic display.

The radiant is located in a region of sky which used to be known as Quadrans Muralis (the Mural Quadrant), which is how the shower gets its name, but Quadrans Muralis is no longer recognised as one of the 88 official constellations.

The radiant location is in the region bounded by Draco, Boötes and Hercules. The Plough asterism is a handy tool for imaging where the radiant is during peak activity. Extend the line from Megrez (Delta (δ) Ursae Majoris) through Mizar (Zeta (ξ) Ursae Majoris) for 1.5x that distance again and you'll be in the general vicinity of the radiant.

In case you struggle identifying Greek-lettered stars, the stars in the Plough are lettered in sequence starting at the west through to the east (at the end of the Plough's handle). As long as you know the first seven Greek letters, α (alpha), β (beta), γ (gamma), δ (delta), ε (epsilon), ξ (zeta) and η (eta), you should be able to locate the stars we mentioned quite easily.

The Quadrantids are expected to reach peak activity around 20:40 UT on 3 January. This represents the period when Earth will be passing through the densest part of the Quadrantid stream. Unfortunately, the radiant will only be around 8° up at this time. A usual Quadrantid shower shows heightened activity for a few hours either side of the peak. The rates will begin to drop off as we head into the morning of the 4th, but the increasing altitude of the radiant should help to compensate to a degree, keeping things interesting through to dawn.

The Moon will be new on the evening of 2 January, which means that on the night of the Quadrantid peak it will not interfere. You will need to find a dark unobstructed observing site and plan to observe in periods no shorter than 30 minutes. Allow your eyes at least 20 minutes in darkness to become dark adapted. A garden recliner makes a great observing platform, but don't forget to wrap up warm!

▲ A Quadrantid meteor train distorting under the influence of high-altitude winds

ALL PICTURES: PETE LAWRENCE

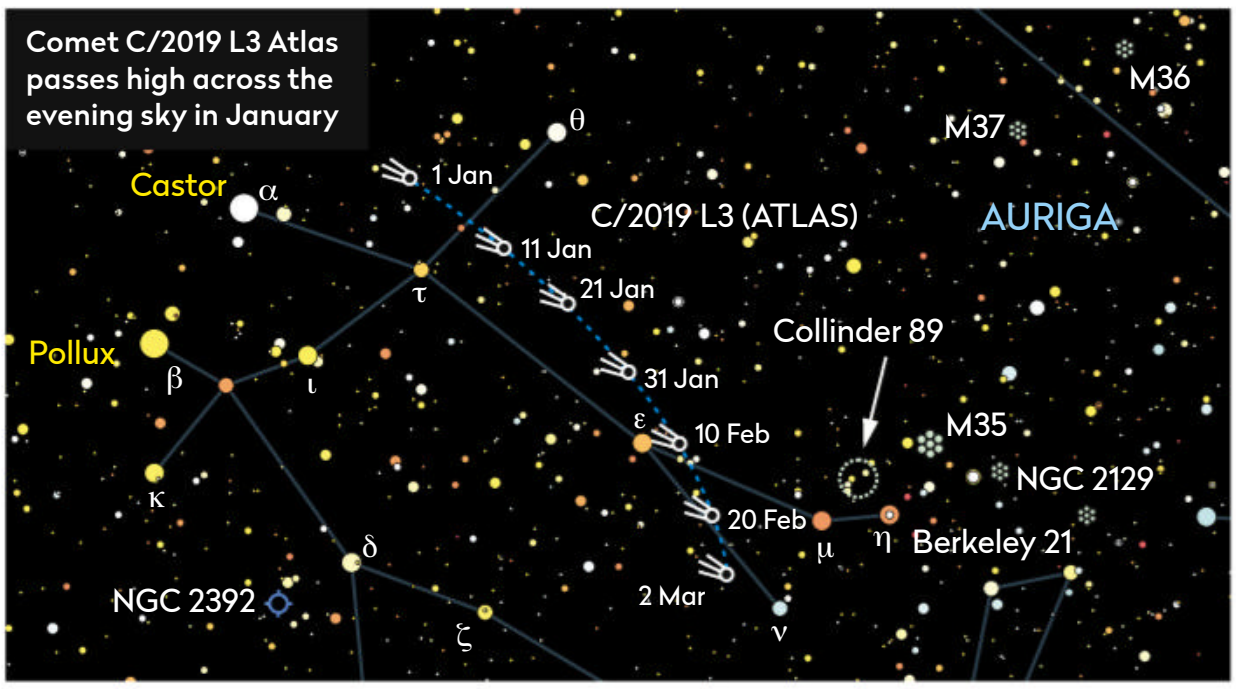
Comet C/2019 L3 Atlas

BEST TIME TO SEE: All month; best at the start and end of January when the Moon is absent

Comet C/2019 L3 Atlas is well placed in January. Reaching perihelion on the 10th, it is expected to reach mag. +9.7, making it a viable target for larger binoculars or a small scope. L3 Atlas was discovered by the ATLAS (Asteroid Terrestrial-impact Last Alert System) facility at Haleakala, Hawaii on 10 June 2019. Around 18th magnitude, it has brightened since then. It is located in the constellation of Gemini, tracking along the northern edge of the stick figure representing the body of the twin Castor.

In terms of brightness, C/2019 L3 Atlas is expected to stay at mag. +9.7 for the first half of the month, dropping a tenth of a magnitude during the second half. If the sky is clear and the Moon is out of the way, it should be easy to keep tabs on.

At January's start, the comet is 3° north of mag. +4.4 Tau (τ) Geminorum, midway between mag. +1.9 Castor (Alpha (α) Geminorum) and mag. +3.4 Theta (θ) Geminorum. It follows a curving path southwest, ending the month 2° north of Mebsuta (Epsilon (ε) Geminorum). The full track length over the month is around 10°.



Slightly brighter than 10th magnitude, L3 Atlas will make a great imaging target for wide-field and close-up study.

C/2019 L3 Atlas isn't the only bright comet. 19P Borrelly is moving northeast as it approaches perihelion on 2 February.

▸ Turn to page 53 to find out more about this potential binocular comet

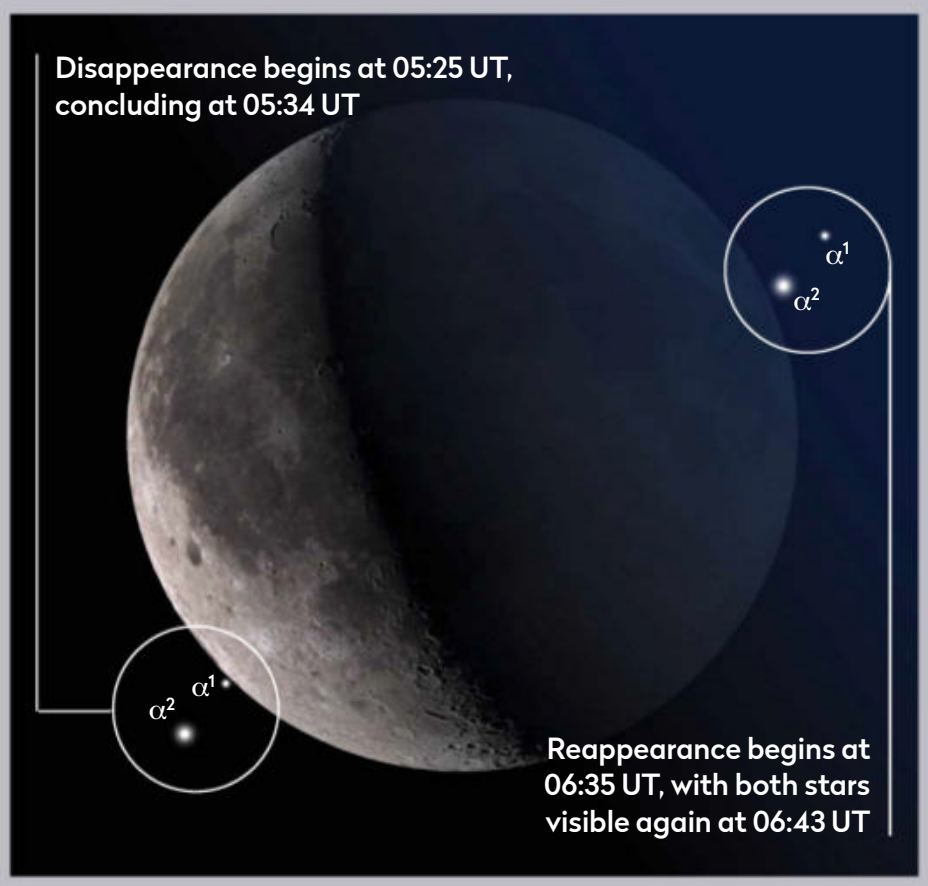
Lunar occultation of Zubenelgenubi

BEST TIME TO SEE: 26 January, from 05:10 UT until 06:50 UT

The 42%-lit waning crescent Moon will pass in front of the star Zubenelgenubi (Alpha (α) Librae) on the morning of 26 January, an event known as a lunar occultation. Bright star occultations aren't rare but are uncommon enough to make them worth putting in a bit of effort to see. In this case there's a hidden bonus because Zubenelgenubi is a double star with both components visible to the naked eye.

The two components are mag. +5.1 Alpha-1 (α^1) and mag. +2.8 Alpha-2 (α^2) Librae. The name Zubenelgenubi, which means 'Southern Claw', applies to the brighter component, Alpha-2. They lie at the same distance of 77 lightyears and both have similar velocity and direction in space. As a consequence, they are very likely to be a physical pair.

From the centre of the UK, the Moon's bright limb will hide Alpha-1 at 05:25 UT, Alpha-2 following suit nine minutes later at 05:34 UT. Alpha-1 reappears from behind the Moon's dark limb at 06:35 UT, Alpha-2 reappearing at 06:43 UT. Dawn will be well underway as the reappearance occurs but both stars are bright enough to remain visible for the event. Times will vary slightly depending on your location so it pays to observe starting, say, 15 minutes before the quoted disappearance and reappearance times.



▲ The lunar occultation of the double star Zubenelgenubi (Alpha-1 (α^1) and Alpha-2 (α^2) Librae) on the morning of 26 January. Times are correct for the UK's centre and will vary with location

THE PLANETS

Our celestial neighbourhood in January

PICK OF THE MONTH

Venus

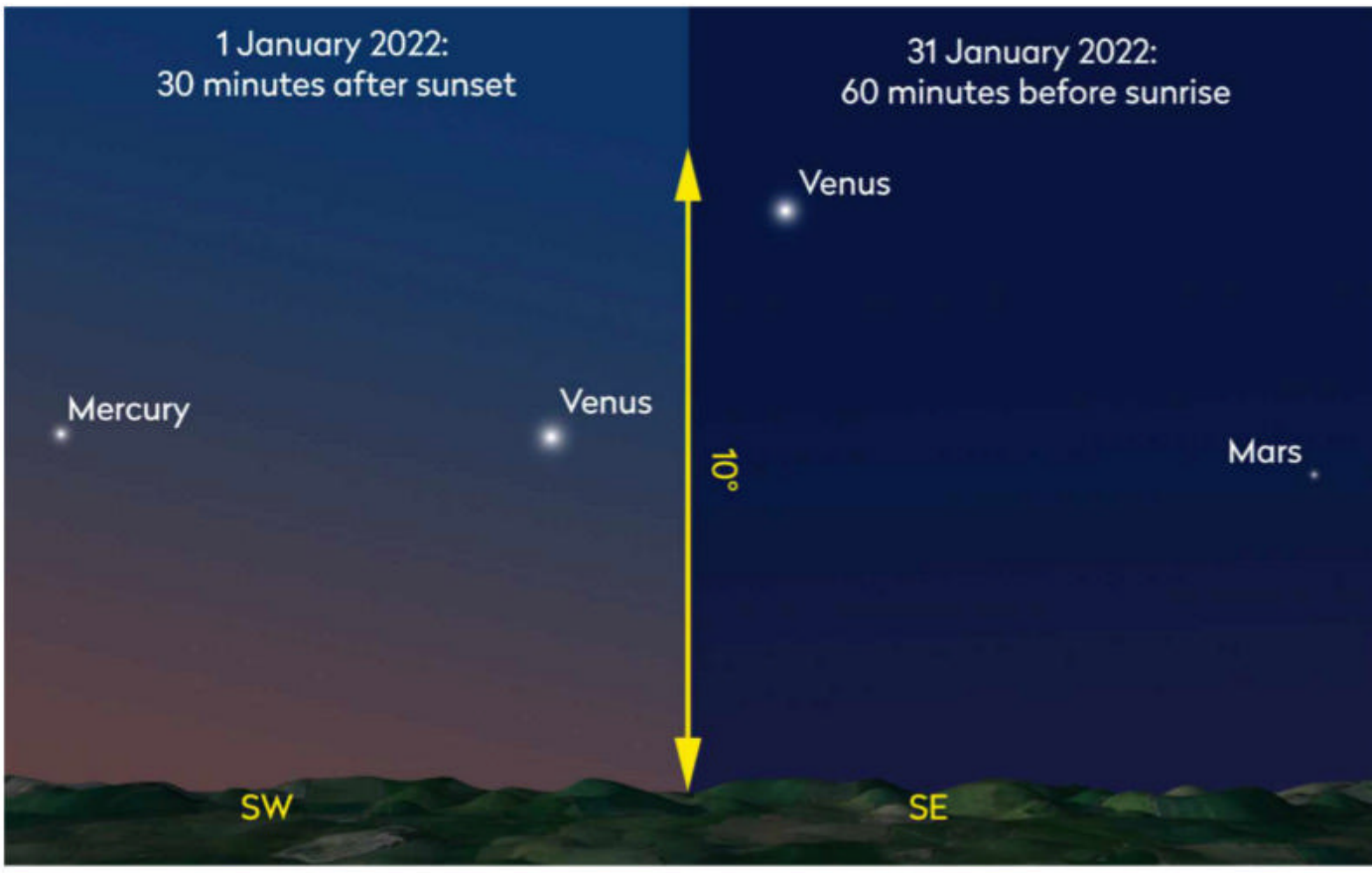
Best time to see: 31 January, 07:00 UT
Altitude: 9° (low)
Location: Sagittarius
Direction: Southeast
Features: Phase, faint shaded markings.
Recommended equipment: 75mm, or larger

Venus is in its crescent phase this month. You might be fortunate enough to catch the planet in the evening sky right at the month's start, but it's heading for inferior conjunction on 9 January so you don't have long. On the 1st, a telescope will show Venus as a slender 2%-lit crescent, a remarkable sight if you have clear skies. Being thin and low in altitude, this crescent is susceptible to the unstable atmosphere we have to look through for objects close to the horizon, so plan to catch it as early as you can after sunset. As ever, be safe when hunting for Venus and make sure the Sun is below the horizon before looking for it. If you're more experienced, it is possible to locate Venus during the day when the Sun is up, but as it's getting close to the Sun now, this is not recommended unless you know what you're doing.

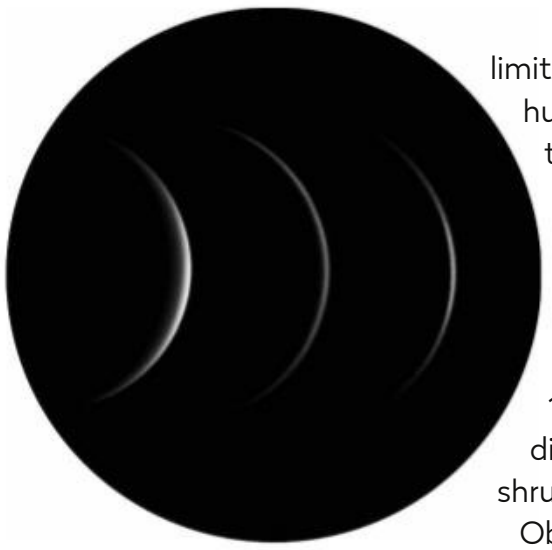
Following inferior conjunction on the 9th, Venus rapidly re-emerges into the morning sky, greatly assisted by the planet being north of the ecliptic plane – the plane of Earth's orbit around the Sun, which also marks out the apparent path of the Sun against the background stars.

On 14 January, a telescope will reveal Venus as a 1%-lit crescent, 1 arcminute across. This is at the limit of resolution for the human eye. On this date the planet rises an hour before the Sun. By the time the end of the month has arrived, the phase of Venus will have increased to 14%-lit, its apparent diameter having shrunk to 49 arcseconds.

Observing Venus will have become a little easier too, the planet now rising 135 minutes before the Sun.



▲ **Venus will appear as a 2%-lit crescent on 1 Jan, and will increase to 14%-lit on the 31 Jan**

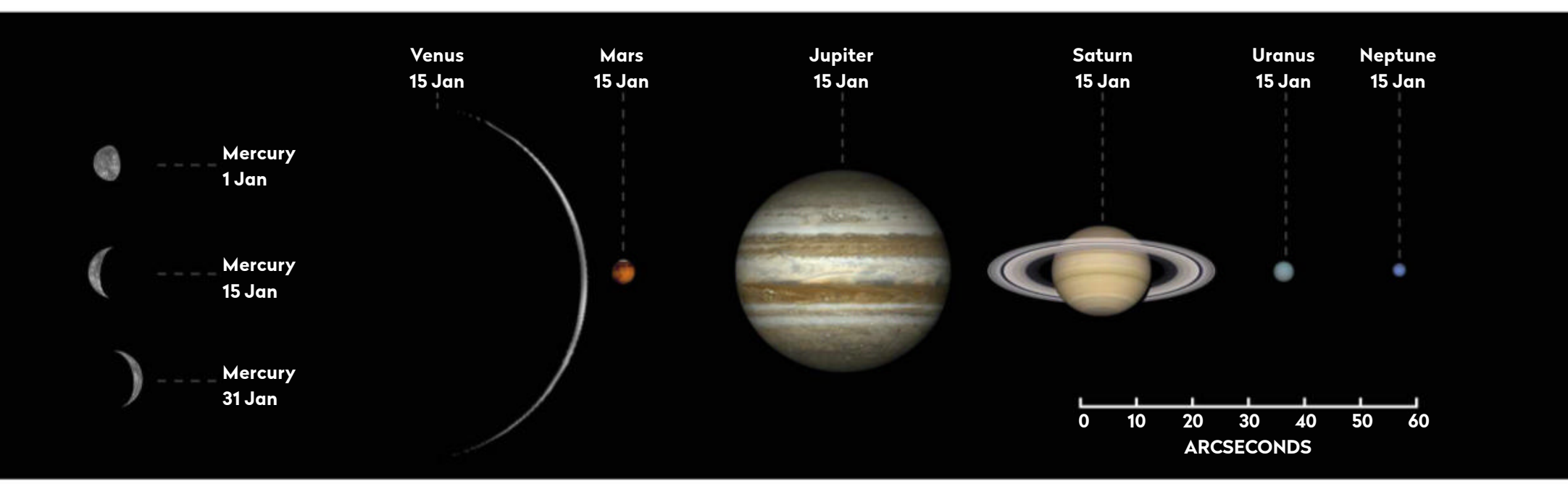


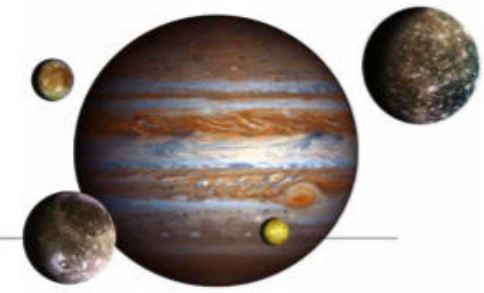
▲ **As a thin crescent, Venus is an incredible sight through a telescope**

PETE LAWRENCE X 3

The planets in January

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 7 January, 30 minutes after sunset
Altitude: 8° (low)
Location: Capricornus
Direction: Southwest

Mercury shines at mag. –0.7 in the evening twilight at the month's start when it sets, with Venus, about 80 minutes after sunset. It reaches greatest eastern elongation on the 7th, setting 100 minutes after the Sun, but dimming to mag. –0.5.

The dimming continues and on the 13th, now shining at mag. +0.4, Mercury appears 3.4° from mag. +0.9 Saturn.

Mars

Best time to see: 31 January, 07:15 UT
Altitude: 6° (low)
Location: Sagittarius
Direction: Southeast

Mars is a morning planet at the start of 2022, rising two hours before the Sun on the 1st when mag. +1.5 Mars lies 5.5° from its sky rival Antares (Alpha (α) Scorpii). This offers a good opportunity to compare the planet with its mag. +1.0 stellar rival; the name Antares means 'rival of Mars'. Mars never gains much altitude under January's brightening dawn.

Jupiter

Best time to see: 1 January, 17:00 UT
Altitude: 23°
Location: Aquarius
Direction: South-southwest

Jupiter is a bright evening planet, visible from 17:00 UT at January's start, 23° above the south-southwest horizon. It shines at mag. –2.0. A waxing crescent Moon passes near Jupiter on the evenings of the 5th and 6th. By the end of January, Jupiter appears against the dusk twilight as its evening observational window draws to a close.

Saturn

Best time to see: 1 January, 17:00 UT
Altitude: 12°
Location: Capricornus
Direction: Southwest

Saturn is an evening planet, but not well placed, affected by the evening post-sunset twilight glow. Mag. +0.9 Saturn is joined by mag. –0.6 Mercury and a thin 5%-lit waxing crescent Moon on 4 January. Look for the trio 80 minutes after sunset. Venus is there too, but closer to the Sun. Jupiter completes the line-up, following 19° to the east. Mercury appears 3.6° from Saturn on the 14th. On this date Mercury and Saturn appear similar in brightness.

Uranus

Best time to see: 1 January, 20:00 UT
Altitude: 52°
Location: Aries
Direction: South

Uranus is well placed at the month's start, reaching over 50° altitude when due south, as seen from the UK's centre. But the planet's visibility degrades towards the month's end. Uranus shines on the edge of naked-eye visibility at mag. +5.7 in southern Aries.

Neptune

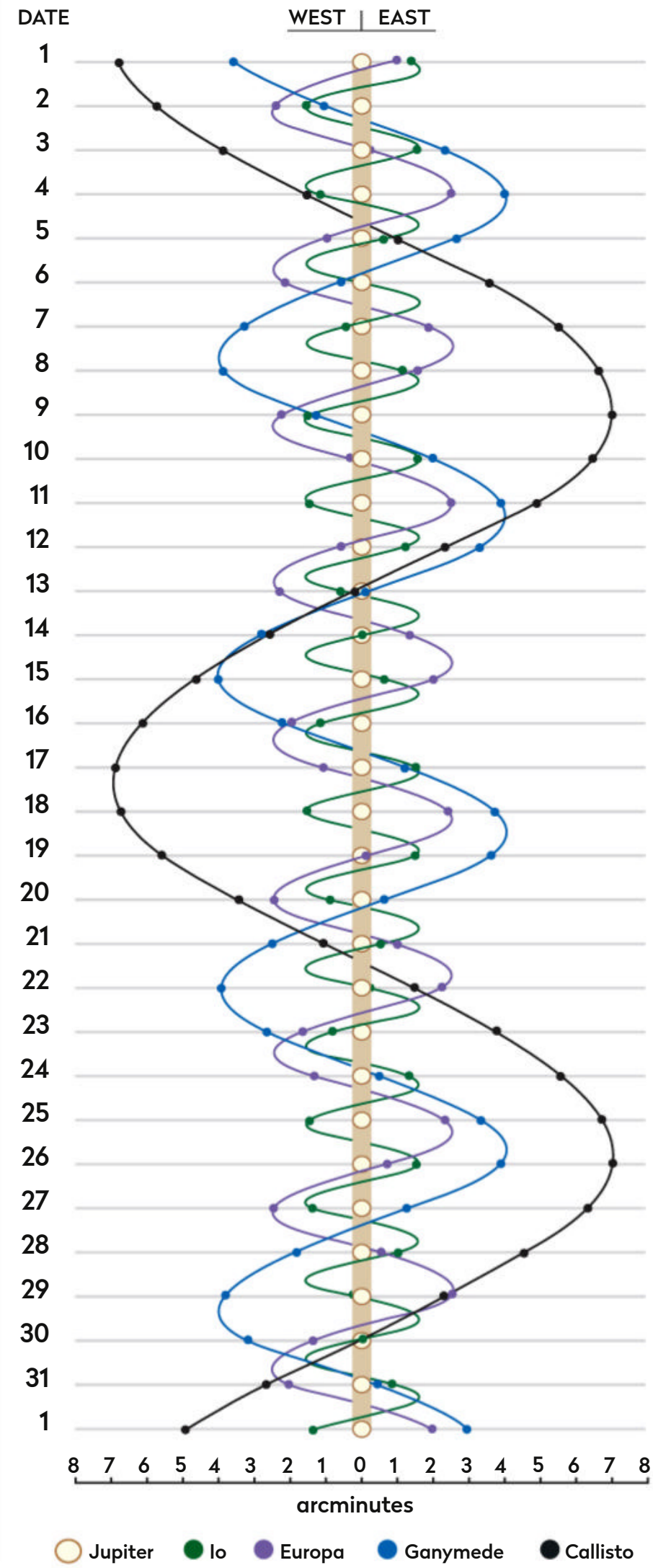
Best time to see: 1 January, 18:15 UT
Altitude: 30°
Location: Aquarius
Direction: South-southwest

On the 1st, mag. +7.9 Neptune is about 30° above the south-southwest horizon as darkness falls. By the month's end, this value will have decreased to 15°. Optical assistance is required to spot Neptune, the minimum equipment being binoculars.

More **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: JANUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – JANUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- 5° N E W S — COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

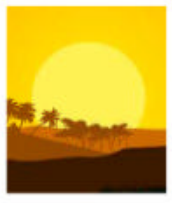
1 January at 00:00 UT
15 January at 23:00 UT
31 January at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in January*



Date	Sunrise	Sunset
1 Jan 2022	08:26 UT	16:02 UT
11 Jan 2022	08:21 UT	16:15 UT
21 Jan 2022	08:11 UT	16:32 UT
31 Jan 2022	07:57 UT	16:51 UT

Moonrise in January*

Moonrise times

1 Jan 2022, 17:18 UT	17 Jan 2022, 15:29 UT
5 Jan 2022, 10:47 UT	21 Jan 2022, 20:28 UT
9 Jan 2022, 11:44 UT	25 Jan 2022, 00:27 UT
13 Jan 2022, 12:42 UT	29 Jan 2022, 06:13 UT

*Times correct for the centre of the UK

Lunar phases in January

Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
1	2 NEW MOON	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17 FULL MOON	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

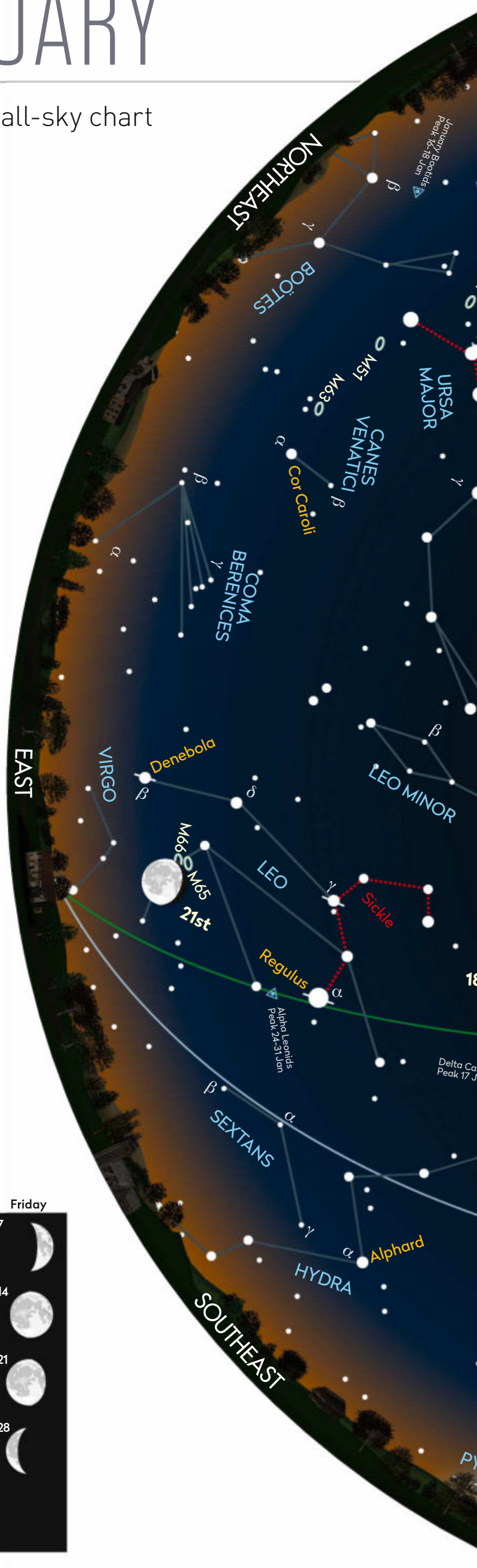
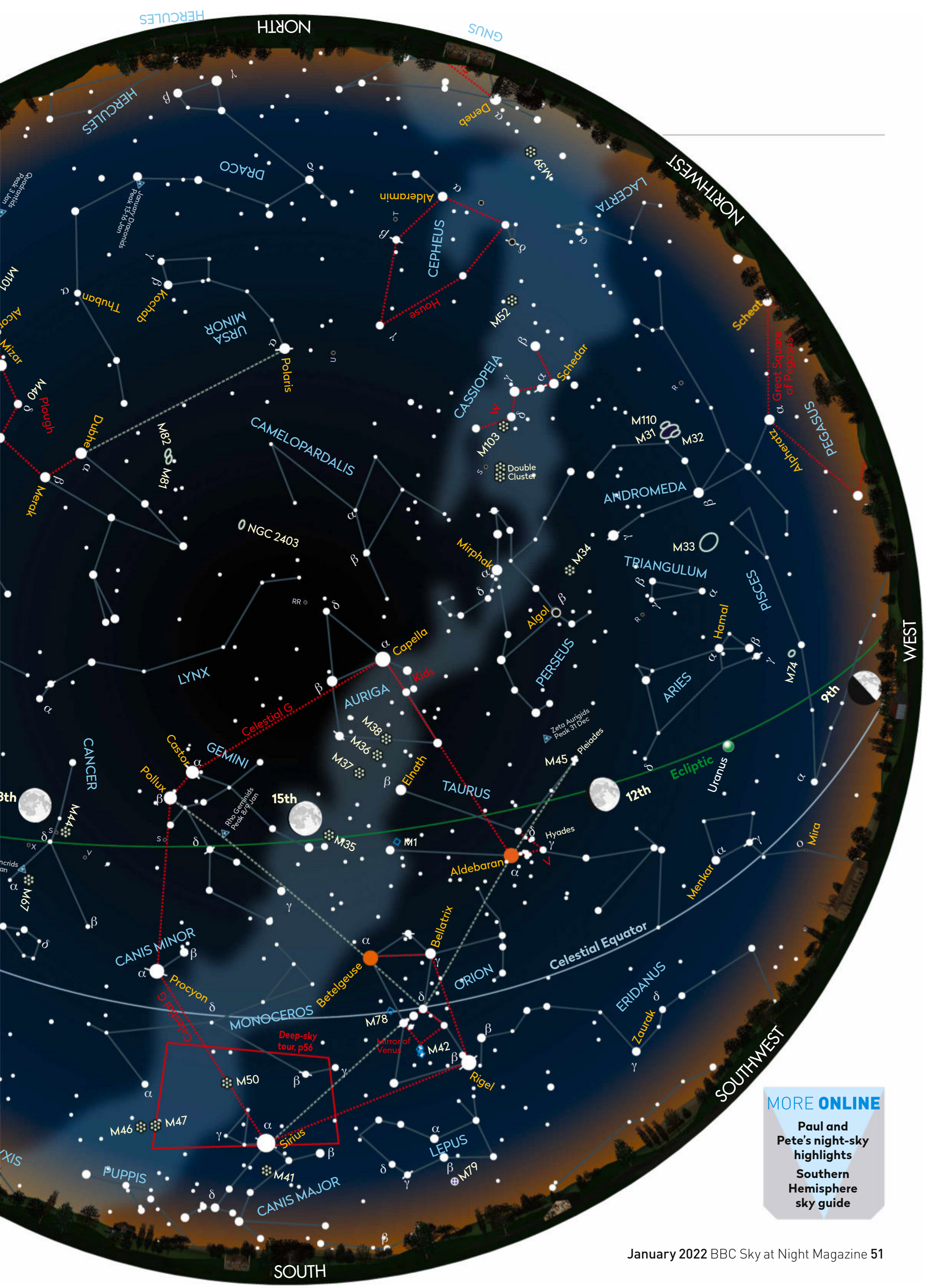


CHART: PETE LAWRENCE



MORE **ONLINE**

Paul and Pete's night-sky highlights

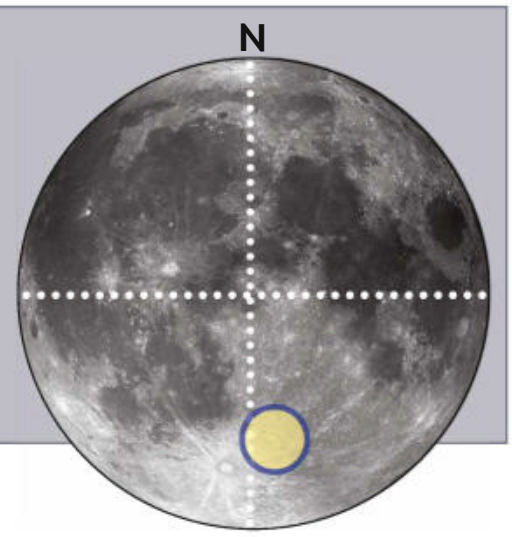
Southern Hemisphere sky guide

MOONWATCH

January's top lunar feature to observe

Nasireddin

Type: Crater
Size: 53km
Longitude/Latitude: 0.1° E, 41.0° S
Age: Approximately 3.8–3.9 billion years
Best time to see: First quarter (10 January) or six days after full Moon (24 and 25 January)
Minimum equipment: 50mm refractor



Nasireddin is a 53km crater located in the rough textured southern badlands area of the Moon. It is a great example of how some lunar features overlap others. When this happens, it's logical to conclude that the overlapping feature is younger than the feature overlapped, a technique used to determine the relative age of surface features.

In this case, Nasireddin overlaps 65km **Huggins**, the western edge of Nasireddin's rim stretching one-third of the way across the larger crater's diameter. Being the overlapped crater, the age of Huggins is estimated to be greater than 3.9 billion years.

To the north lies **Miller**, a 75km crater that presents more of a problem. If you look carefully at Miller and Nasireddin, they appear to touch, but it's not obvious whether an overlap has occurred. If anything, the curving edge of Miller looks subtly dominant in that its natural curve persists along the co-joined section. Consequently, Miller's age is estimated to be in the same range as Nasireddin, about 3.8–3.9 billion years.

Nasireddin has a sharp rim edge exhibiting plenty of terracing. Compare Nasireddin's rim with that of Huggins. The latter looks much smoother and rounded without much obvious terracing. Miller looks like a larger version of Nasireddin.

Nasireddin's central floor area is very rough, its texture appearing richly detailed when the Sun's angle is low. There are a number of small craterlets visible here, along with many hill bumps. The crater is described as having a central mountain complex, but it's not immediately obvious where this starts and the surrounding hills end. Again, compare Nasireddin to Miller to the north. Miller's central complex is much better defined, with smaller peaks surrounding a main peak.

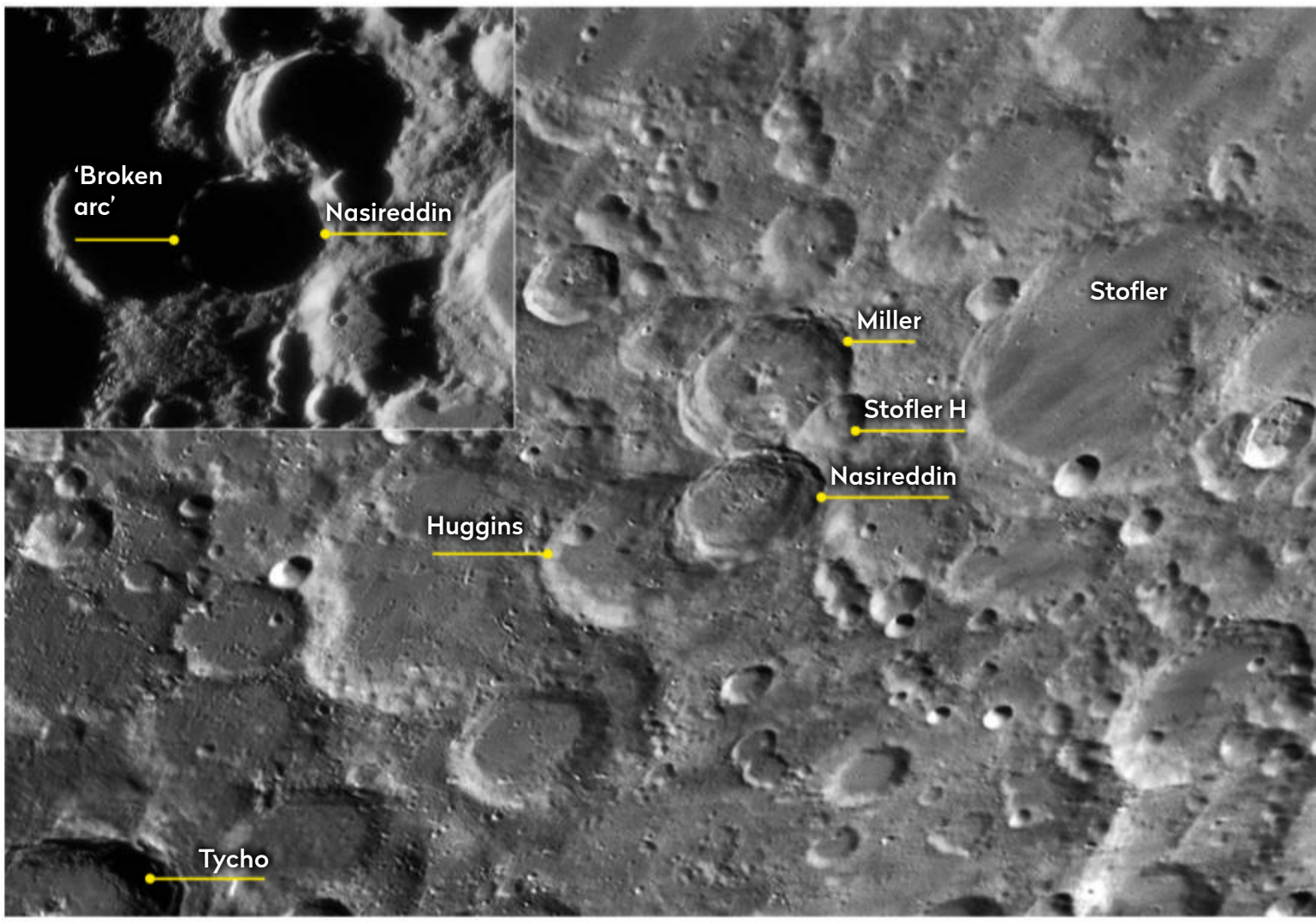
Nasireddin has an unusual rim illumination around co-longitude 2.6°. Lunar co-longitude is a value which indicates the location of the morning terminator; that's the one which creeps across the Moon's face from new Moon, through the waxing phases until full Moon. It's measured in degrees from when the terminator touches the Moon's line of zero longitude, the lunar equivalent of Earth's Greenwich meridian.

At first-quarter Moon, the co-longitude value is close to 0°. It then increases to approximately 90° at full Moon, 180° at last quarter and 270° at new Moon. The 'approximately' label is due to lunar libration, which causes the Moon's prime meridian to shift relative to the more geometrically defined phase positions. At co-longitude 2.6°, the Moon's early morning light catches regions around Nasireddin's edge, causing the rim outline to appear as a series of short dashes, a clair-obscur effect we've called the 'broken arc'.

Nasireddin's texture is rough, appearing richly detailed when the Sun's angle is low

▼ When morning light catches Nasireddin's edge, the rim appears as a series of dashes, forming a 'broken arc' clair-obscur effect

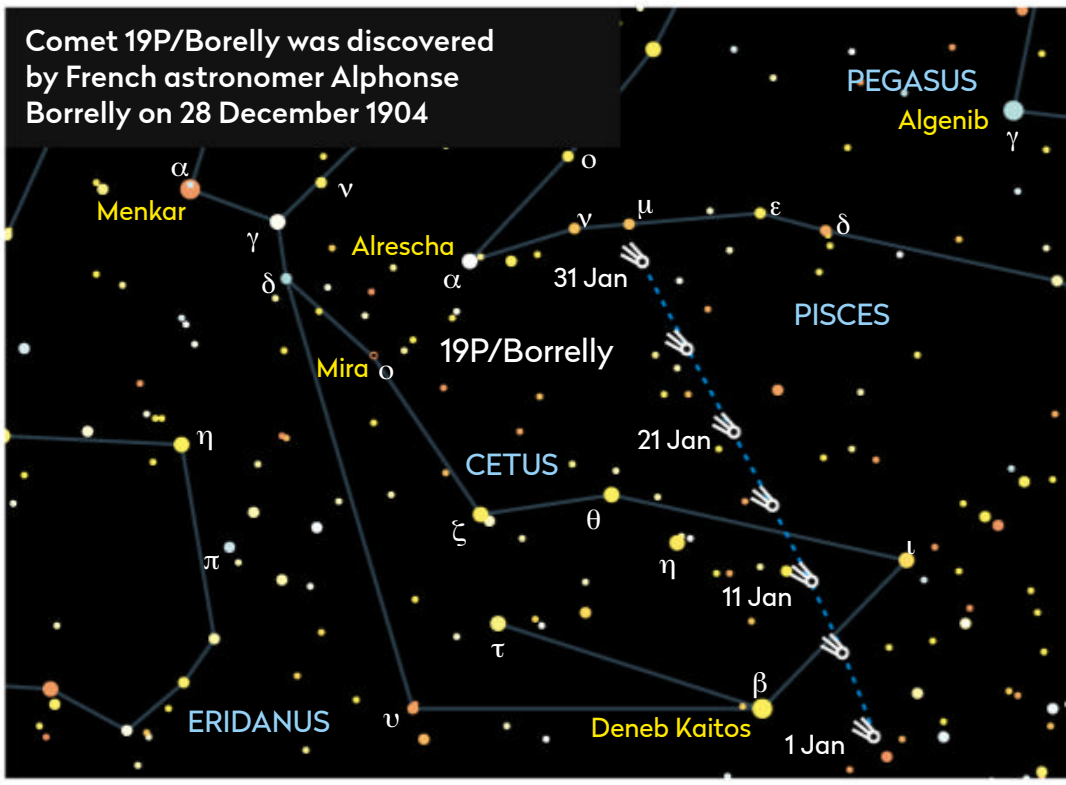
Nasireddin lies 270km east of the 86km ray crater **Tycho**. The rugged nature of Nasireddin doesn't allow ejecta debris from the much younger Tycho to stand out, and this is evident on the dark floor of the 126km walled plain of **Stofler**, east of Nasireddin.



PETE LAWRENCE X 3

COMETS AND ASTEROIDS

Comet 19P/Borrelly will make a good target from the Northern Hemisphere



Comet 19P/Borrelly is potentially visible using binoculars and should be a great target for small telescopes. It joins comet C/2019 L3 ATLAS in January's night sky to produce a great cometary feast.

The comet is currently moving northeast and brightening as it goes. Starting the month in Cetus, not far from mag. +2.0 Deneb Kaitos (Beta (β) Ceti), the comet remains inside the Cetus boundary for much of the month, managing to slip into Pisces at the end of January. On the evening of 1 January, 19P sits 5° west of Deneb Kaitos, visible after evening twilight has subsided and true darkness has descended, just after 18:00 UT. This places the comet slightly to the west of south, around 19° up as seen from the centre of the UK.

By the month's end, 19P is predicted to have brightened to mag. +8.9 and, located 3° southwest of mag. +4.9 Mu (μ) Piscium on the evening of the 31st, its altitude will have improved too, the comet appearing about 34° up as true darkness arrives. This is despite the region of sky containing Borrelly having naturally drifted further west of south as darkness falls.

We know about the comet thanks to a visit by the Deep Space 1 probe in 2001. Its nucleus is 8km x 4km x 4km and it follows an elliptical orbit, which takes it out as far as 5.83 AU from the Sun and in as close as 1.35 AU, the distance the comet will be from the Sun at perihelion on 1 February. It takes Borrelly 6.8 years to make one orbit. Its closest approach to Earth is 55 million km.

STAR OF THE MONTH

Look for Saiph, at the knee of Orion

Saiph (Kappa (κ) Orionis) is one of the main pattern stars in Orion, marking its southeast corner. Saiph is typically shown marking one of Orion's knees, although the formal translation of the name means 'sword', from the Arabic *saif al jabbar*; 'sword of the giant'.

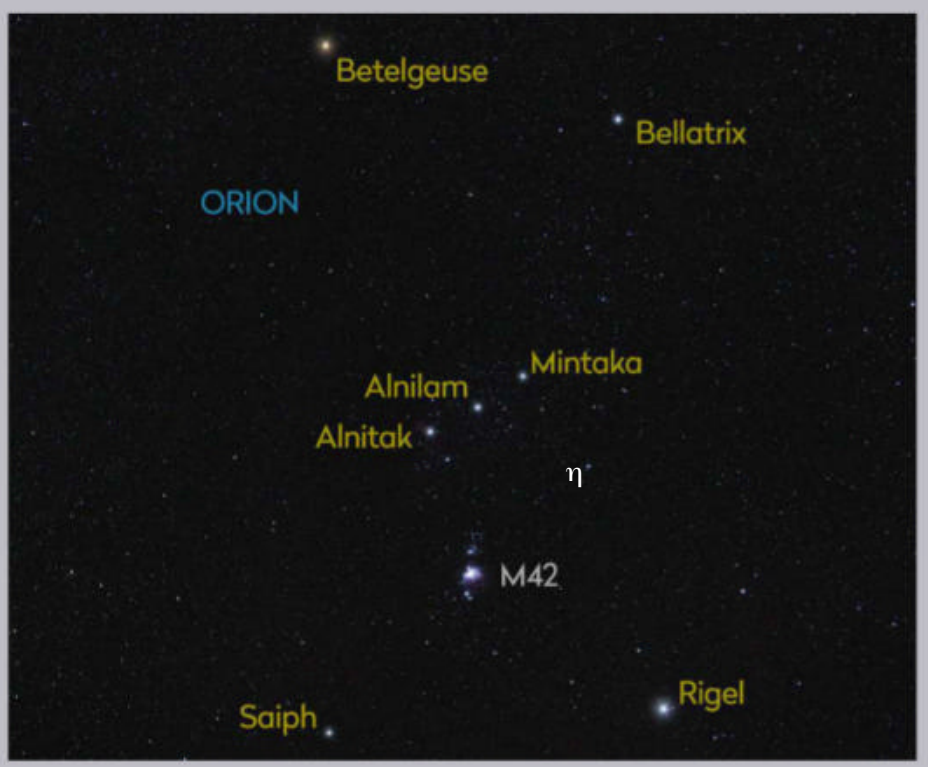
Interestingly, the name was originally attributed to Eta (η) Orionis, which sits west of the three Belt stars in Orion.

It is said that Saiph's name was originally attributed to what we call Orion's Belt today, but got mistakenly transferred to Kappa, where it remained.

Saiph is the sixth brightest star in Orion, appearing fainter than two of the Belt stars, but marginally brighter than Mintaka (Delta (δ) Orionis) at the Belt's western end. It's a bright, B-class supergiant that appears to shine blue-white to us. Its spectral class is B0.5 Ia, 'Ia' indicating the luminosity class 'bright supergiant'.

Saiph is estimated to lie at a distance of 650 lightyears, which makes it closer than Rigel (Beta (β) Orionis), another blue supergiant at a distance of 860 lightyears. Despite this, Rigel appears much brighter to us, a characteristic attributed to the fact that Saiph is an extremely hot star with an effective temperature of 26,227°C. Consequently, it radiates much of its light in the ultraviolet part of the spectrum which we can't see with our eyes. Rigel is a multiple star system, but the main component Rigel-A, has an effective temperature of 11,826°C.

▼ **Saiph will eventually collapse in on itself, resulting in a cataclysmic supernova explosion**

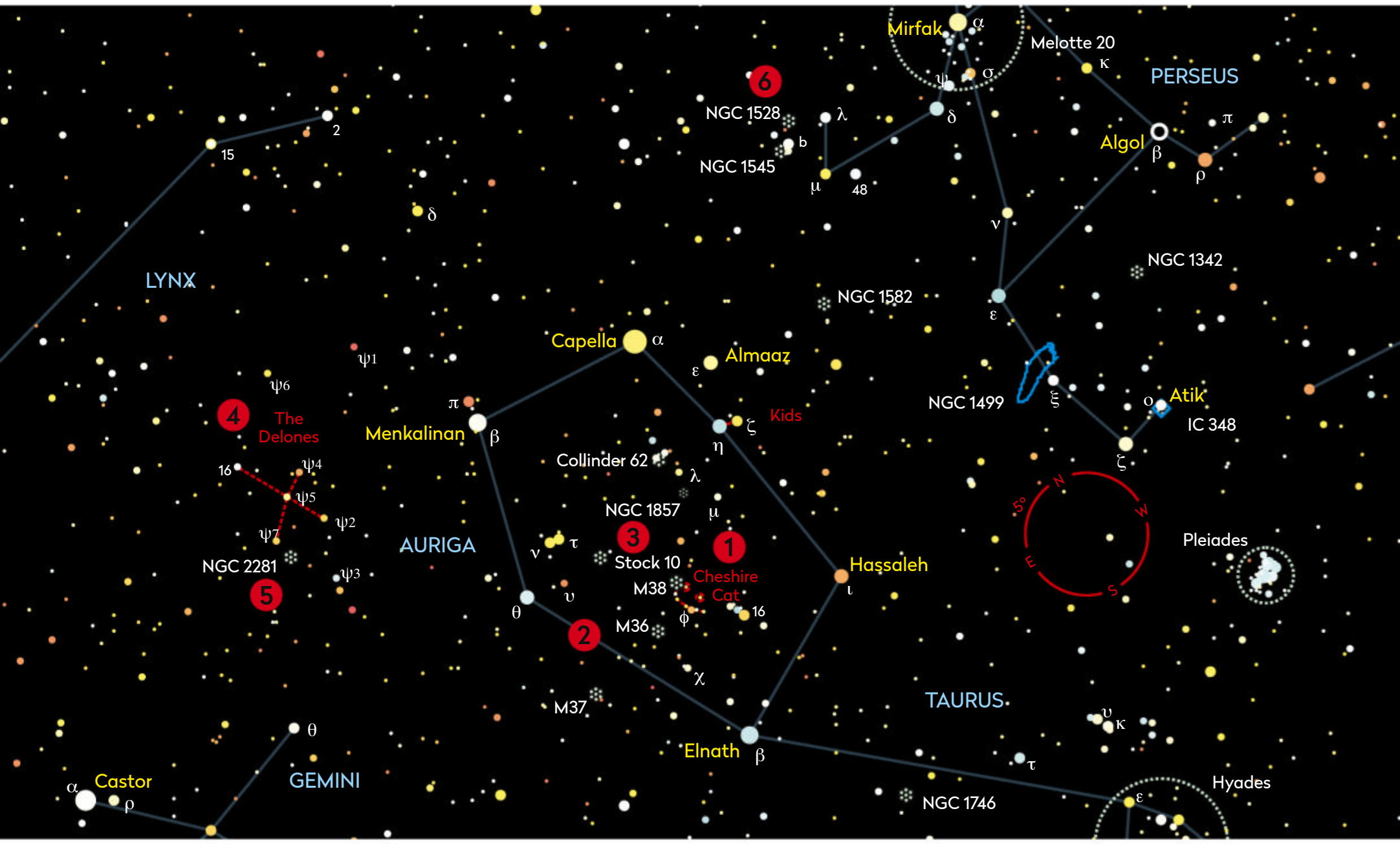


Estimated to be around six times more massive and 22 times larger than the Sun, Saiph's luminosity is around 57,000 times greater.

BINOCULAR TOUR

With Steve Tonkin

Meet the Cheshire Cat and discover the cross asterism of the Delones



1. The Cheshire Cat

10x 50 How nice to be welcomed to the sky with a smile! Yellow Phi (ϕ) Aurigae is the brightest star in the 'grin' of mostly 6th and 7th magnitude stars that extends for about 1.5°, with another widely spaced pair of stars – the yellowish eyes – 0.5° to the west. Other than a small group of 8th magnitude stars that gives the merest hint of the disappearing nose, that's all that remains of the Cheshire Cat. ☐ **SEEN IT**

2. The Auriga Trio of Clusters

10x 50 At the northern end of the Cheshire Cat's smile, you will see a fuzzy patch. That is the Starfish Cluster, M38, and a couple of degrees southeast you'll find another one, M36. Now put M36 at the northwest of the field and yet another fuzzy patch, larger and brighter than either of the previous two, is visible to the left of centre of the field of view. This is the Salt and Pepper Cluster, M37. ☐ **SEEN IT**

3. Stock 10

10x 50 Stock 2 is about the same size as M37, but is a very sparse cluster that can be tricky to distinguish from the background Milky Way. You'll find it at the third point of a triangle with Tau (τ) and Upsilon (υ) Aurigae. The brightest three stars form a distinct little arc, which you can use to confirm that you are in the right place, but note how all the stars clump into little sub-groups. ☐ **SEEN IT**

4. The Delones

10x 50 Traditionally, the Delones (Psi (ψ) Aurigae) group of 5th magnitude stars represented the ends of the lashes of the Charioteer's whip. Then Maximilian Hell used them to honour William Herschel's discovery of Uranus with a depiction of his telescope. The variety of colours makes this a rewarding region for binoculars. Note the cross asterism formed by Psi-2 (ψ^2), Psi-4 (ψ^4), Psi-5 (ψ^5) and Psi-7 (ψ^7) Aurigae and 16 Lyncis. ☐ **SEEN IT**

5. NGC 2281

15x 70 The cross asterism of the Delones is a good guide to our next open cluster. NGC2281 lies less than a degree southwest of Psi-7 Aurigae. This is a loose but rich cluster that benefits from the magnification of larger binoculars – it looks like a nebulous patch in smaller ones. If you look carefully, you may see that the central 'star' is a tiny rhombus of 9th magnitude stars. ☐ **SEEN IT**

6. The Other Double Cluster

15x 70 Look midway between Capella (Alpha (α) Aurigae) and Mirphak (Alpha (α) Perseii) and the more obvious of the double, NGC 1528, will present as a rich, compressed cluster much like M38. NGC 1545, slightly more than a degree to the southeast, is smaller and sparser, but brighter. At 2,500 lightyears away, they are a similar distance from us. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Can you spot the phase of Venus with the naked eye over the month of January?

After 8 January, the phase of Venus increases as its apparent diameter shrinks (see table below). This diminishes the opportunity to make out the planet's shape with the naked eye

Venus wasn't the easiest planet to spot in 2021. Loitering in the evening sky after sunset, its altitude has been low. It is visible in the evening sky before inferior conjunction on 9 January 2022, after which it re-emerges in the morning sky. Venus is the brightest of the planets, regularly appearing brighter than mag. –4. It also has the largest potential apparent size, something which is only achieved close to inferior conjunction. The challenge is to see whether you can spot the planet's phase with your eyes only.

When Venus is close to inferior conjunction, it appears through the eyepiece as an ultra-thin crescent. It also approaches the theoretical limit of naked-eye resolution, at 1 arcminute; it will appear larger than 1 arcminute between 1-17 January and it's not uncommon to 'see' the phase of Venus when staring at it. Unfortunately, this often turns out to be down to visual errors in your eye's optical path rather than a true phase. Don't worry, Venus is tricky in this respect!

A common issue when viewing a bright point source of light is the presence of astigmatic rays that emanate from the point, which can produce the appearance of a crescent shape. If you see a clear shape to the planet, tilt your head. If the shape appears to rotate, it is in your head.

Part of this challenge will be to locate Venus itself (see page 48). As it is close to the Sun, make sure you observe safely, and only when the Sun is below the horizon. Consider enlisting help from someone who (a) you know has good eyesight, and (b) knows little about astronomy or Venus.

Date	Phase (%)	Diameter (arcseconds)
1 January 2022	0.025	60.9
2 January 2022	0.020	61.4
3 January 2022	0.015	61.8
4 January 2022	0.011	62.1
5 January 2022	0.008	62.4
6 January 2022	0.006	62.6
7 January 2022	0.004	62.7
8 January 2022	0.003	62.8
9 January 2022	0.003	62.7
10 January 2022	0.004	62.7
11 January 2022	0.005	62.5
12 January 2022	0.008	62.3
13 January 2022	0.010	62.0
14 January 2022	0.014	61.7
15 January 2022	0.018	61.3
16 January 2022	0.023	60.8
17 January 2022	0.028	60.3
18 January 2022	0.034	59.7
19 January 2022	0.041	59.1
20 January 2022	0.048	58.5
21 January 2022	0.055	57.8
22 January 2022	0.063	57.1

▲ Use this table to check the phase and apparent diameter of Venus over the month

Don't prompt them with any information, just ask them to look hard at the planet and write down what they see. If they can see a shape to the planet, ask them to draw its orientation relative to the horizon.

Another thing to try is to use a large sheet of card with a hole, placed some distance from you. Looking at Venus through the hole without the distraction of its surroundings may help. Remember, if you see something, does its orientation stay the same if you tilt your head?

This is a scientific experiment and as such you may report a negative result, which is fine. If you experience a positive result, we'd love to hear from you, along with the date, time and details of any method used. Enjoy the challenge!

DEEP-SKY TOUR

Take flight around Monoceros with the Seagull Nebula and make a final stop in Canis Major

1 NGC 2232

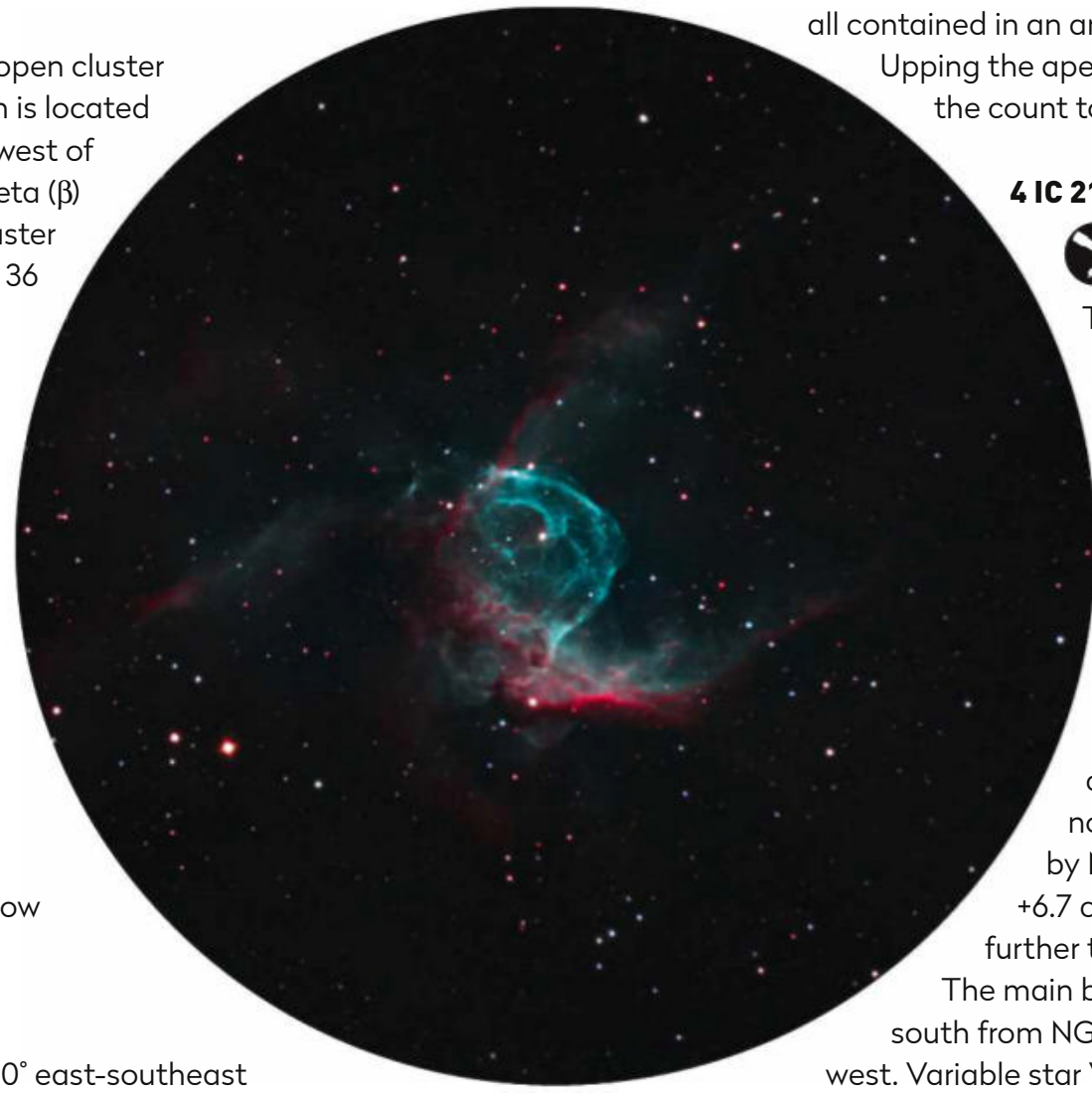
Our first stop is open cluster NGC 2232, which is located 2.4° to the north and a bit west of the telescopic triple star Beta (β) Monocerotis. It's a large cluster with an overall diameter of 36 arcminutes, its core region appearing 7 arcminutes across. NGC 2232 is centred on the mag. +5.0 star 10 Monocerotis, which tends to dominate the proceedings. Two spindly 'legs' of stars appear to hang south from 10 Monocerotis, extending for 0.4°. To the north lies a gap, before a small grouping of sixth magnitude stars is seen. The group is attractive at low powers. ☐ **SEEN IT**

2 M50

M50 lies nearly 10° east-southeast of NGC 2232, or 4.2° northeast of mag. +4.1 Theta (θ) Canis Majoris, the star marking the tip of the Great Dog's nose. It's a bright, compact cluster which is well resolved at 100x power using a 150mm instrument, the view through the eyepiece revealing 70-plus of the cluster's 600 or so members. Visually, the resolved stars in the cluster give it a non-round shape; it is also known as the Heart-Shaped Cluster. A 250mm scope shows a rich cluster containing 150 stars in an area 25 arcminutes across. Many of its stars appear blue-white in colour. ☐ **SEEN IT**

3 NGC 2335

NGC 2335 is a mag. +7.2 open cluster located 1.9° south-southeast of M50. It's also the gateway to the Seagull Nebula, IC 2177 (this tour's next object). The cluster sits north of the middle of a right-angled triangle formed from mag. +7.0 HIP 34357, mag. +8.1 TYC 5385-1690-1 and mag. +7.9 TYC 5385-0206-1. Many open clusters have some defining pattern or shape and NGC 2335 is no different, containing four stars between mag. +9.5 and +11.2 that form a diamond or rhombus pattern in its core. A 250mm scope reveals about 25 stars in the cluster, all contained in an area 10 arcminutes across. Upping the aperture to 300mm increases the count to 40 stars. ☐ **SEEN IT**



▲ **NGC 2359 is known as Thor's Helmet, as the curving extensions resemble the helmet's wings**

4 IC 2177

Our next target is large and faint. The Seagull Nebula, IC 2177, is an emission nebula with a low surface brightness due to it covering an area 120 x 40 arcminutes. It is possible to see sections of the nebula using smaller instruments, but you'll need a low power and a dark sky. A narrowband nebula filter can work wonders here. The northern 'wing tip' is marked by NGC 2335, with the mag. +6.7 cluster NGC 2343, 0.7° further to the south-southeast. The main band of nebulosity drops south from NGC 2335, curving to the west. Variable star V750 Monocerotis (mag. +7.0 to +8.4), 0.7° southwest of NGC 2335 appears surrounded by a haze (Gum 1). ☐ **SEEN IT**

5 NGC 2353

NGC 2353 is an open cluster located a bit south and 2° east of NGC 2335. It's dominated by mag. +6.0 HIP 34999, located south of the cluster's centre. It is not part of the cluster, its association being nothing more than line-of-sight. The cluster's core is compact and surrounded by three stars, of magnitudes +8.8, +9.2 and +9.8, arranged in an equilateral triangle. A 250mm instrument reveals 30-plus stars scattered across an area 10 arcminutes across. One of the problems viewing NGC 2353 is the richness of the background Milky Way; it's an object easily lost against the star field it's in. A large aperture will reveal a multitude of stars, shining between mag. +9.0 and +11, in a 20-arcminute region. ☐ **SEEN IT**

6 NGC 2359

The last target requires us to slip across the border into Canis Major. NGC 2359 is located 3° south and 0.7° east of NGC 2353. A small scope will reveal a rectangular patch of nebulosity, about 4 x 1 arcminutes in size, and the appearance is assisted by the use of an OIII (oxygen) or UHC (ultra high contrast) filter. With increased aperture more nebulosity appears, a faint circular feature appearing to the north of the brighter rectangle. The circular feature is a bubble formed by the stellar wind from mag. +11.5 HIP 35378 at its centre. ☐ **SEEN IT**

MICHAEL DEGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

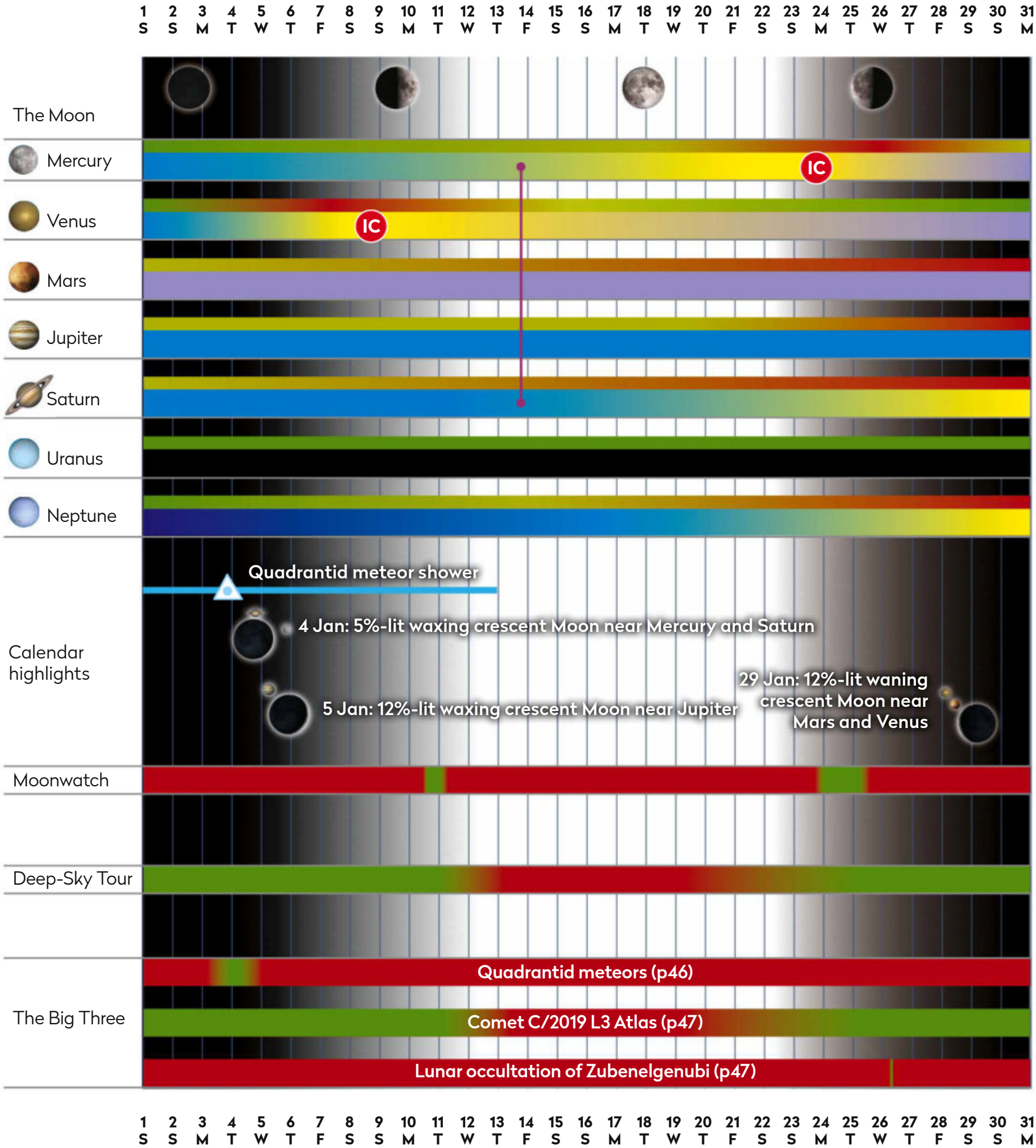
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

07h30m
07h00m
06h30m
-05°
-10°
-15°
MONOCEROS
CANIS MAJOR
NGC 2311
Bochum 3
NGC 2250
10
NGC 2232
1
NGC 2309
NGC 2302
β
NGC 2215
2
M50
HIP 33959
HIP 34357
3
NGC 2335
TYC 5385-0206-1
5
NGC 2353
HIP 34999
TYC 5385-0206-1
V750
Gum 1
NGC 2343
IC 2177
4
Gum 3
NGC 2396
Haffner 8
6
Haffner 6
NGC 2359
NGC 2345
NGC 2374
θ
2°
1°
N
E
W
S
PK 218-10.1

AT A GLANCE

How the Sky Guide events will appear in January



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

Sega Toys Homestar Flux

Satin Black

Imagine enjoying the sky full of stars while sitting on your sofa. This dream can become reality with the Sega Toys series of home planetariums.

Flux is the most powerful and most advanced model available to date. Crafted in a satin-like finish, this powerful star projector is designed to be your first choice home planetarium.

Brilliant glass lenses and our brightest LED to date make everything look vibrant and sharp.
The indicated edges of a lunar crater surrounding the lens finish the look.

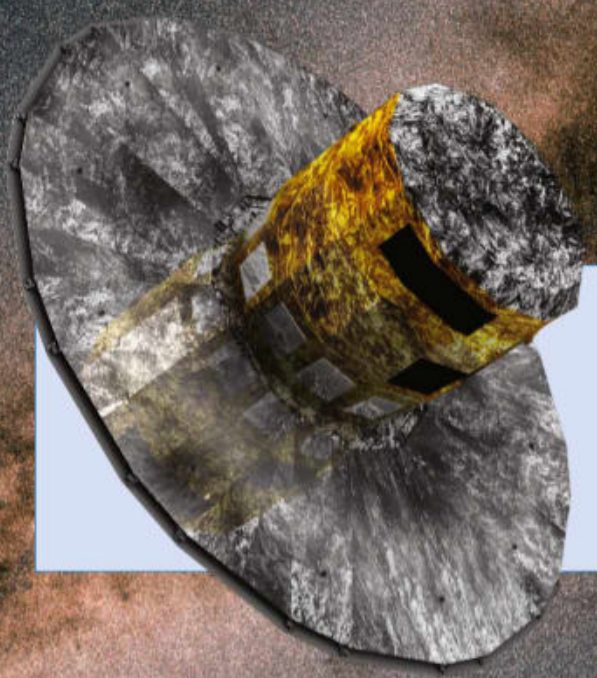
SEGA TOYS flx

www.segatoys.space 174GBP

Exploring space with Sky at Night Magazine

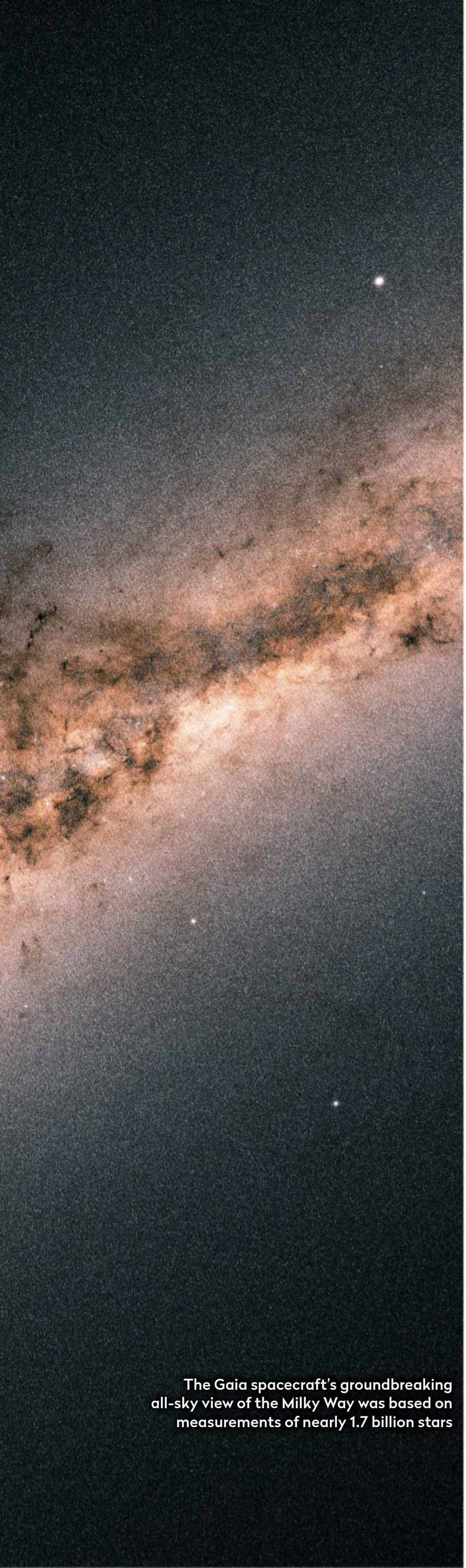
For 200 issues, *BBC Sky at Night Magazine* has been at the forefront of reporting on space exploration and science. **Chris Lintott** looks back at some of the most important events

There's a vivid memory I have, of sitting around Patrick Moore's dining room table and discussing the idea for what later became *BBC Sky at Night Magazine*. One of the people present – who shall remain nameless – wondered if there would be enough material to fill its pages month after month. Looking back at how much the team has crammed into the first 200 issues, it's fair to say that finding enough content hasn't been a problem. The anniversary has provided a wonderful excuse to look back, whether it's to cover missions to Pluto, to revisit a rather special comet, or to return to exoplanet discoveries that have transformed the search for life in the cosmos and much more. Read on for my highlights!



Gaia maps the Milky Way

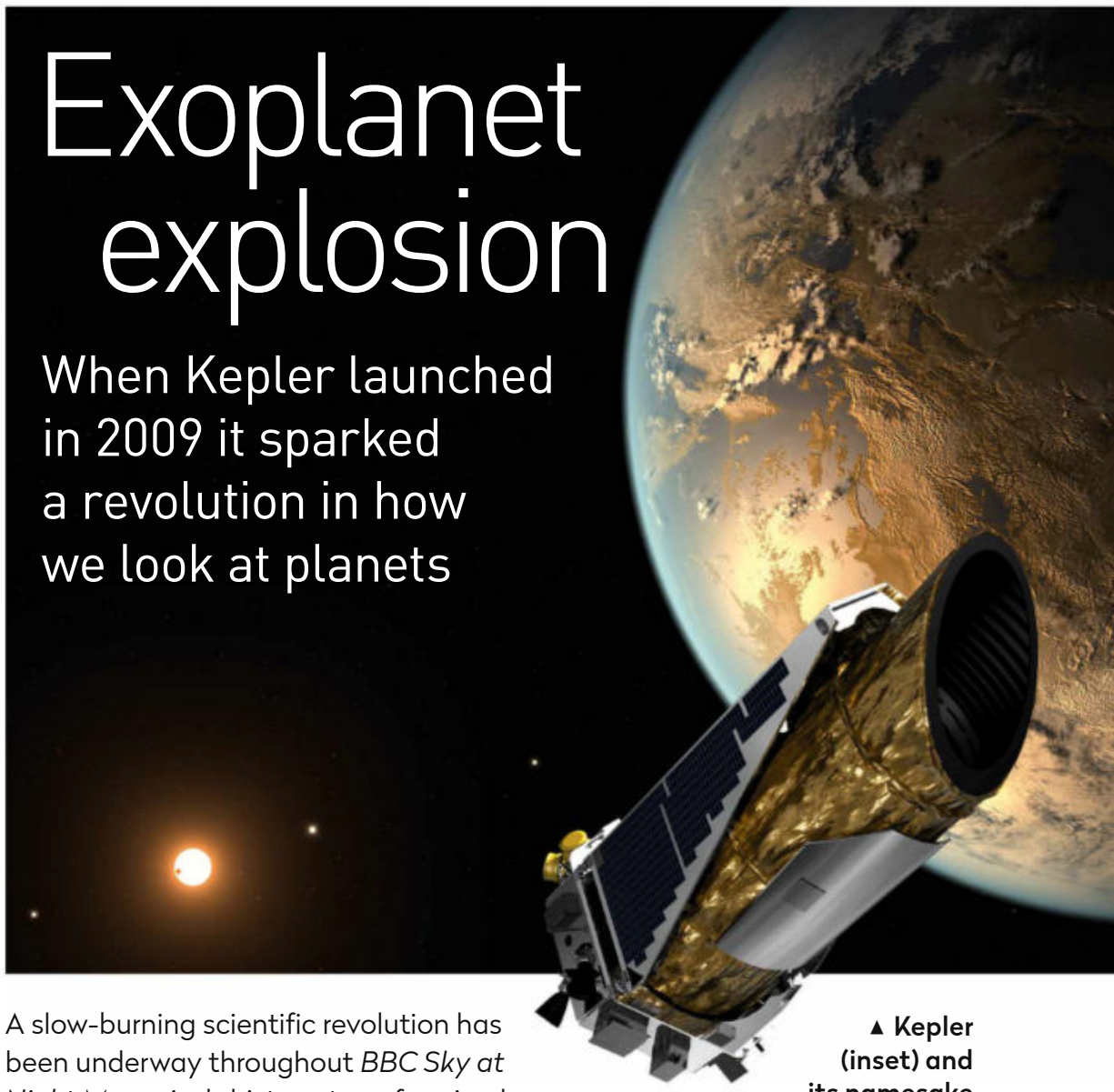
Astronomy has its roots in mapping the night sky, and the latest and greatest map has been provided by ESA's Gaia spacecraft. Gaia launched in 2013 and since then it has painstakingly recorded the position and movements of the nearest billion or so stars, allowing researchers to trace the Milky Way's history like never before.



The Gaia spacecraft's groundbreaking all-sky view of the Milky Way was based on measurements of nearly 1.7 billion stars

Exoplanet explosion

When Kepler launched in 2009 it sparked a revolution in how we look at planets



ILLUSTRATION

▲ **Kepler (inset) and its namesake exoplanet 186f**

A slow-burning scientific revolution has been underway throughout *BBC Sky at Night Magazine*'s history, transforming how we view the Universe. Thanks to the incredible precision achieved by instruments both on Earth and in space, we now know that planets are common around the stars of the Milky Way, and presumably throughout the Universe. The Kepler Space Telescope in particular, built in the hopes of discovering a mere handful of planets, delivered a cosmic bounty that was way beyond the dreams of its builders. We can now look at the night sky as one filled with the potential of millions of worlds.

And what worlds they are. From hot Jupiters, so close to their parent stars that they are literally boiling away, to what seem to be ocean worlds, and from Tatooine-like planets with two suns in their skies, to lost worlds wandering between the stars, almost every kind of planet you can imagine has been found. Surprisingly, the most common type of planet, a super-Earth – sitting between our own world and something like Uranus or Neptune, size-wise – doesn't even exist in our Solar System, and the old explanations for the clustering of our rocky worlds close to the Sun with gas giants further out may no longer hold.

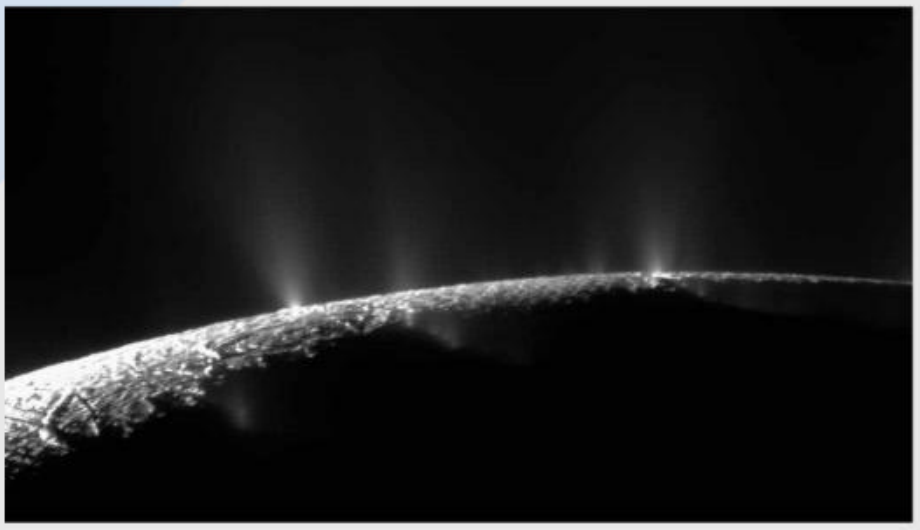
Of course, finding another Earth has long been a dream of scientists and science-fiction authors alike. Depending on how picky you are, the discovery in 2014 of Kepler-186f, an Earth-sized world in the habitable zone of another star may be the moment that dream came true. If Kepler-186f has a similar atmosphere and composition as our Earth, then it's likely it would provide a hospitable home for our kind of life.

There are many other planets to be found, and instruments and surveys on the way to do the job. But the last two decades will always be the period when we truly realised just how many neighbours our Solar System has. ►

ESA, ESA/GAIA/DPAC, NASA/AMES/JPL-CALTECH/T PYLE, NASA AMES/SETI INSTITUTE/JPL-CALTECH

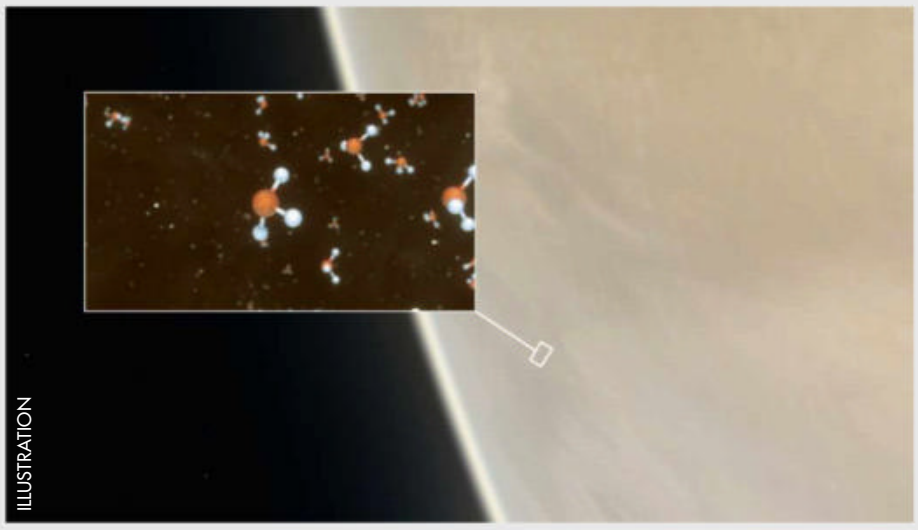
Our planetary neighbours

Dozens of missions over the last 16 years have helped us unravel the mysteries of our Solar System, and find a few new ones



Cassini spies water jets over Enceladus

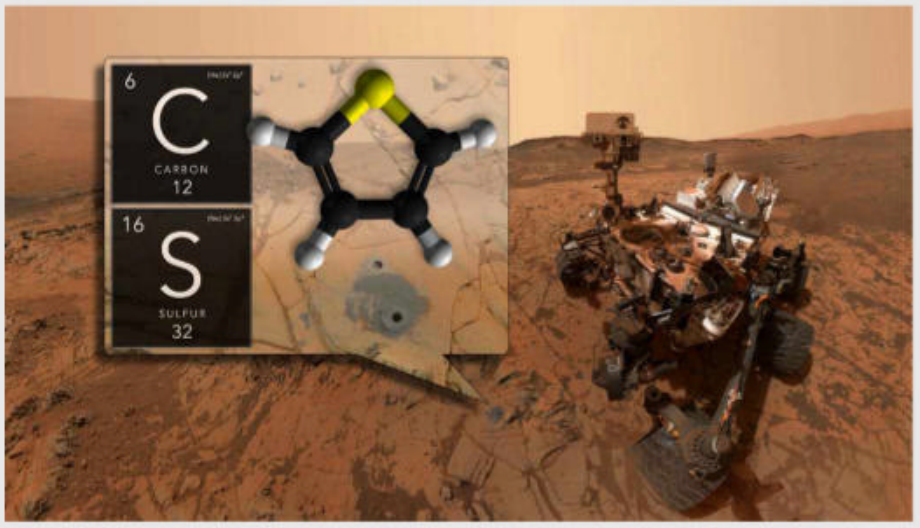
The Cassini spacecraft's flybys of Saturn's moon Enceladus, which started in 2005, transformed our view of this tiny world. While passing over the moon's south pole, Cassini flew through fountains of water, betraying the existence of an ocean beneath its icy surface. These fountains turned out to be the source of Saturn's tenuous E-ring and, more importantly, make this previously obscure world perhaps the best place in the Solar System to look for life. With increasing evidence for subsurface oceans on Jupiter's moons Europa and Ganymede, and maybe even on Pluto, such environments may be much more prominent than rocky worlds like our Earth.



Phosphine on Venus

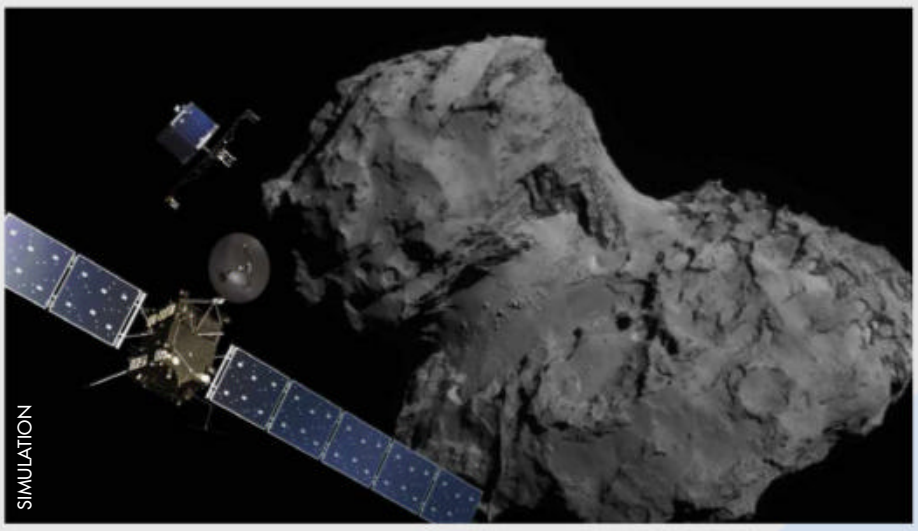
This might be a controversial choice, but I had to include 2020's announcement of the discovery of phosphine molecules high in the atmosphere of Venus by Professor Jane Greaves, based at Cardiff University, and a team of international astronomers.

Phosphine on Earth is produced only by life, and so as we reported in an exclusive episode of *The Sky at Night* its presence might – I stress, *might* – indicate the presence of life in a location where it was least expected. The Cardiff team's results have been criticised, but the controversy will only be resolved by new data, which is expected to arrive soon. (An artist's impression, inset, above, shows a representation of phosphine molecules.)



Methane on Mars

Mars has been the target of more missions during *BBC Sky at Night Magazine*'s lifetime than any other object, and together they have told us a roughly coherent story about the Red Planet's past. We can now be sure it was once a wet world, with oceans and lakes, and all the raw materials for life in place. Yet new questions have arisen, chief among them the reason for the methane detected occasionally by the Curiosity rover, starting in 2013, but which is strangely not detected from orbit. Is it a sign of life clinging on with methane-producing bacteria under the Martian surface, the result of a geological process, or an instrumental artefact or a contaminant? We just don't know.



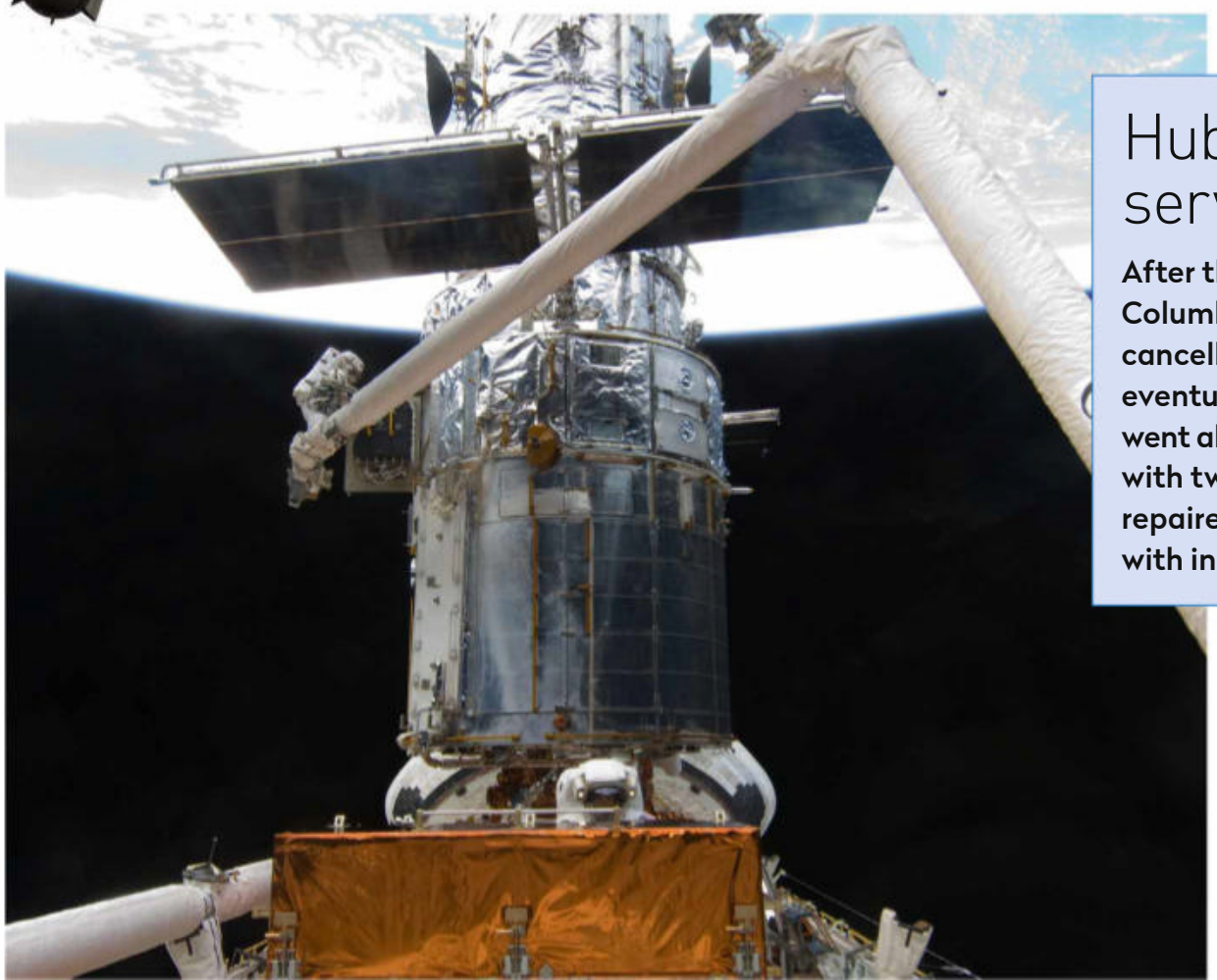
Rosetta explores a comet

Of all the missions I've been lucky enough to cover, and to write about, Rosetta is special. The spacecraft's adventures visiting Comet 67P/Churyumov–Gerasimenko provided excitement from the moment the spacecraft woke up from hibernation in 2014 and approached the duck-shaped comet, right up until its eventual impact with the surface in 2016 – a moment I witnessed from mission control. In between we had the plucky Philae lander bouncing across the surface and a European spacecraft matching any of NASA's epic missions of exploration. Scientists are still puzzling over what Rosetta told us about the mysterious icy object it visited, but Rosetta was clearly a triumph.

A stunning view of Pluto, taken when the New Horizons probe was 450,000km from the dwarf planet

New Horizons flies by Pluto

To Dr Alan Stern, the leader of the team that designed, built and flew the New Horizons mission, its reconnaissance of Pluto completed the American exploration of the main Solar System bodies. The images of this fascinating – and surprisingly complex surface – taken during its flyby on 14 July 2015 astounded and amazed the world.



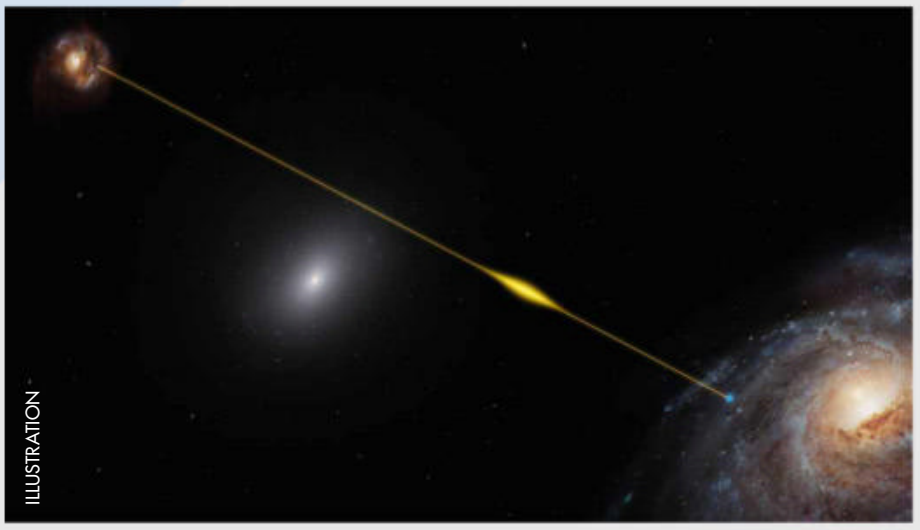
Hubble's last servicing mission

After the tragic loss of the Space Shuttle Columbia, Servicing Mission 4 was initially cancelled. Determination and bravery eventually led to a rethink, and the mission went ahead in May 2009. It fixed major problems with two of the space telescope's instruments, repaired systems never designed to be fiddled with in orbit and installed new hardware. ▸

◂ Astronaut John Grunsfeld works on Hubble during its last service mission, aboard the Space Shuttle Atlantis

The distant Universe

As bigger and better observatories have become available, astronomers have taken ever deeper surveys of the secrets of the cosmos

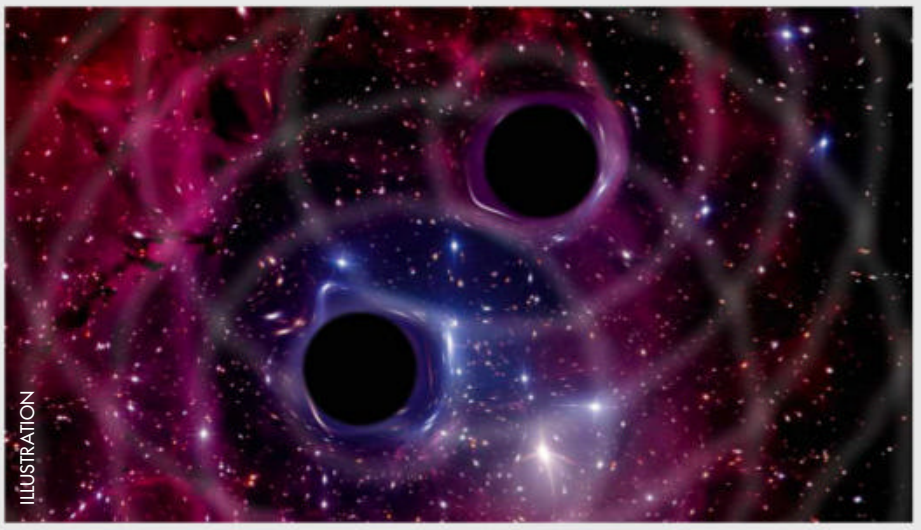


ILLUSTRATION

Fast radio bursts

When Duncan Lorimer and David Narkevic went looking for pulsars in old data from the archives of the Parkes radio telescope in Australia in 2007, they didn't know they were about to make one of the most exciting discoveries in decades.

They found the 'Lorimer burst' recorded in the Parkes data in 2001, which became the first fast radio burst (FRB) to be described. It is now known that these still mysterious events come from distant galaxies, and that they may be the result of collisions of neutron stars, or in some cases the result of such a body interacting with a massive, main sequence star. With thousands of FRBs catalogued, time will tell what they are.

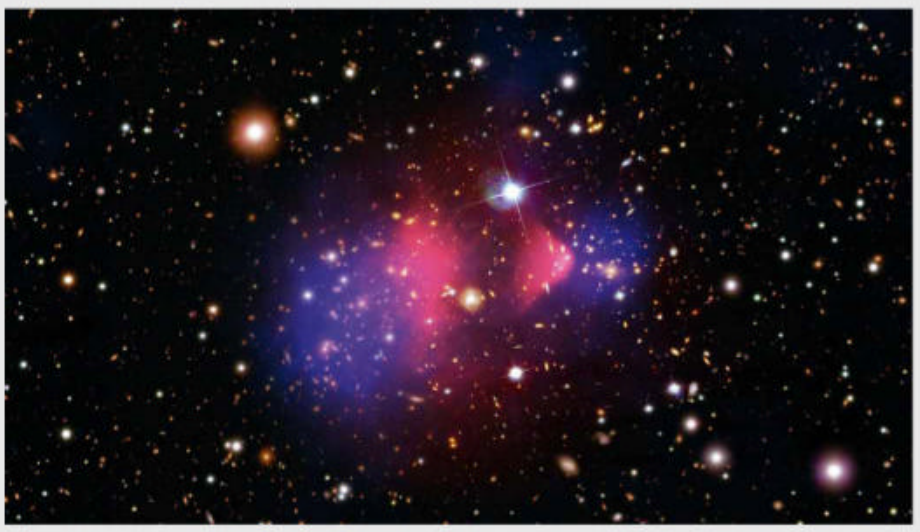


ILLUSTRATION

Gravitational waves

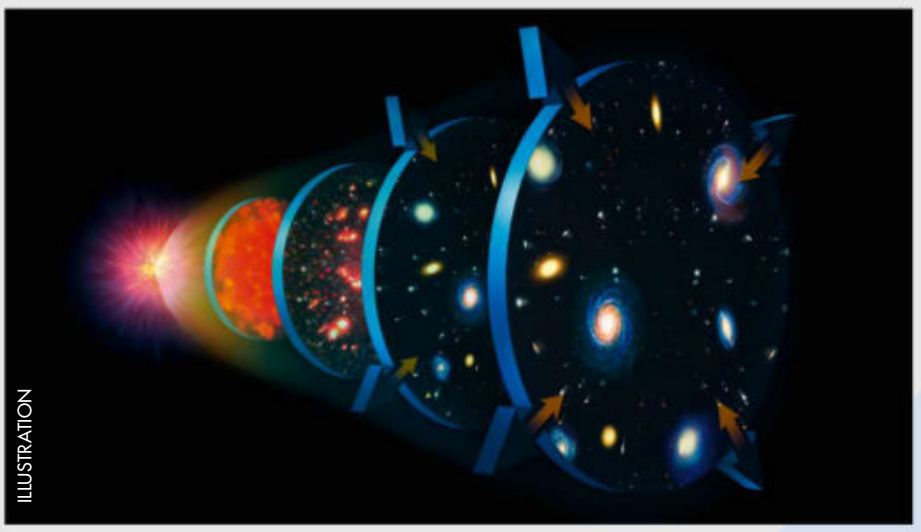
A spectacular triumph of experimental physics that builds on more than four decades of hard work, the detection of the first gravitational waves by the Laser Interferometer Gravitational-Wave Observatory (LIGO) experiment in 2015 provided a new test of Albert Einstein's theories, opened up a new window on the Universe and set the stage for what will be a major part of the story of 21st-century physics.

The ripples in space-time detected by LIGO are tiny, but they brought us news of some of the most violent and energetic processes in the Universe: the collision of two black holes in a far distant galaxy, 1.3 billion lightyears away.



Dark matter in the Bullet Cluster

When the magazine began, I had hoped that, by now, we'd have some idea of what the Universe is made of. Yet with no compelling experimental evidence to support what type of particle is responsible for dark matter, alternatives (such as tweaking the theory of gravity) are looking more alluring. And yet, in the last 16-plus years, dark matter's effects on the movement of stars and galaxies has been seen more clearly. In the mid 2000s, astronomers mapped the mass of the Bullet Cluster and found the distribution was different to what was expected with only normal matter, even when you use an alternative theory of gravity, providing evidence that dark matter is real.



ILLUSTRATION

The Hubble tension

The big cosmological news during the lifetime of *BBC Sky at Night Magazine* isn't really a single discovery, or the dramatic vindication of a new theory, but rather a growing sense that something is actually missing from our understanding of the Universe around us.

The so-called Hubble 'tension' reflects a stubborn disagreement between the speed of the Universe's expansion as measured locally and the one inferred from observations of the early cosmos. Is this a vital clue that leads us to some technical detail of how observations are made? I don't know, but neither does anyone else.

The rise of private spaceflight

From carrying shoebox-sized satellites to full human crews, private spaceflight has come a long way in the last decade

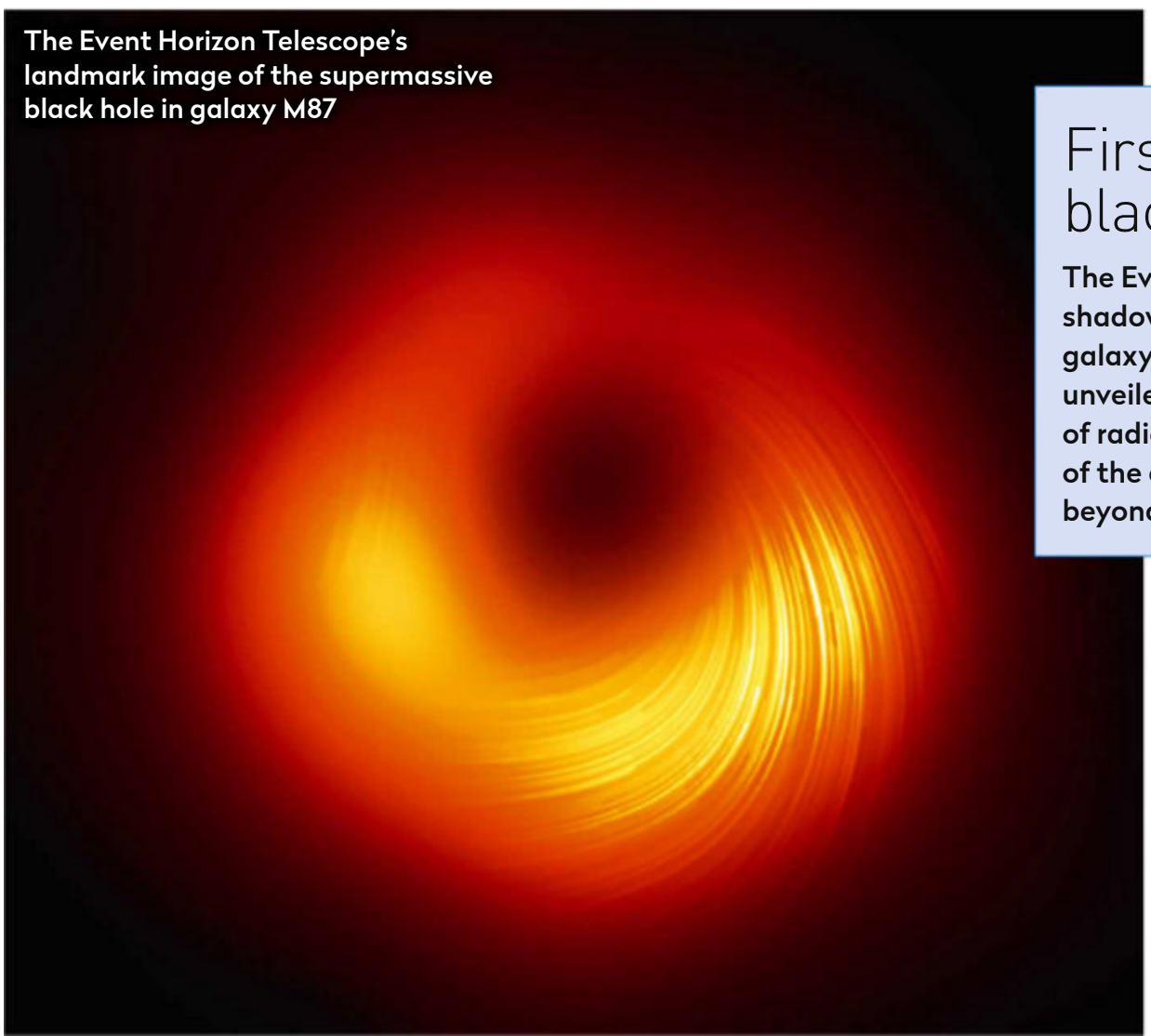
I remember vividly the moment I realised that SpaceX was going to be a transformative company. Sitting in front of my laptop towards the end of 2012, I watched as the Grasshopper test rocket (a prototype of what would become the Falcon 9) lifted gently off the ground, ascended into the air and then, as no rocket before it had done, lowered itself gently back down to the pad. Until then, the considerable achievements of SpaceX, including the launch of Dragon to the ISS had seemed like a useful way of reproducing what governments had been doing for decades. Now, the prospect of a truly reusable vehicle capable of reaching orbit promised something new.

Buzz about 'new space' companies goes back at least to the year before the launch of *BBC Sky at Night Magazine* – after SpaceShipOne's capture of the $10m Ansari X-prize for reaching space twice in 2004. Now, almost 17 years since the magazine began, the promise of those early dreams is being realised, with SpaceX ferrying NASA astronauts to the ISS, Blue Origin taking billionaires (and William Shatner) on the joyride of a lifetime, and companies competing to launch satellites for prices their customers wouldn't have dreamed of a decade ago.

The next 20 years will reveal the impact of this shift. Will the cost of sending something to orbit decrease spectacularly? Will the momentum carry explorers to the Moon, Mars or beyond? Will tens of thousands of satellites in low Earth orbit obscure our view of the night sky forever? We're about to find out.

Elon Musk's SpaceX Dragon docks with the ISS in 2017...

...and Jeff Bezos enjoys a flight to space on Blue Origin's New Shepherd in July 2021



The Event Horizon Telescope's landmark image of the supermassive black hole in galaxy M87

First image of a black hole captured

The Event Horizon Telescope image of the shadow of the black hole at the heart of the galaxy M87 was an instant classic when it was unveiled in 2019. Produced by a global network of radio telescopes, it reveals the complexity of the events taking place in the region just beyond the black hole's event horizon.

Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

The greatest sights to observe in 2022

The New Year of stargazing starts here, as **Katrin Raynor-Evans** looks forward to 12 months of inspirational astronomical events

Astronomers everywhere will welcome the next year with open arms, ready to embrace an astronomical calendar bursting with comets, occultations, meteor showers and supermoons. Many of these exciting events will be visible with the naked eye or a pair of binoculars, and there will also be occasions when a telescope is needed.

If your New Year's resolution is to take up stargazing, then this guide will help you get started. You will be amazed at what you can see with just a little bit of time, some basic research (such as your location and the direction you are facing) and patience. To get your bearings you can use our monthly 'Sky Guide' or download a planetarium app on your phone. Many of us will be getting new observing equipment at this time of year and now is the best time to assemble that new telescope, or unbox the new pair of binoculars, and enjoy the night sky.

Remember, stargazing is for everyone, so let's get stuck in and savour everything that the New Year skies have to offer!

Katrin Raynor-Evans is an amateur astronomy writer and is Features Editor for the Society for Popular Astronomy

January to March

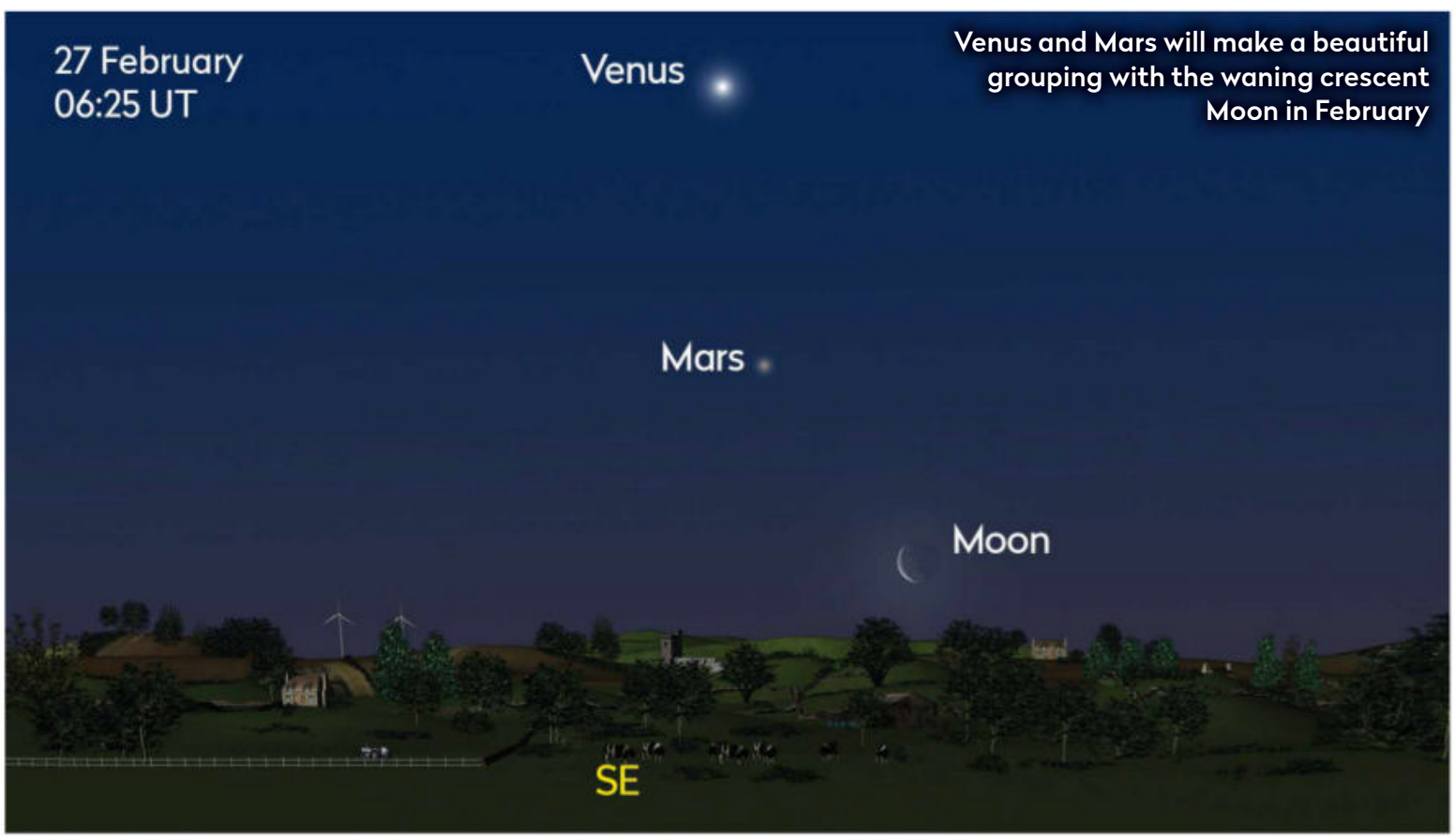
We begin the year when the nights are still very cold, so grab a blanket, a hot drink and step outside into the crisp cold air to enjoy the annual Quadrantid meteor shower. Kicking the year off, the meteor shower takes place on the night of 3 January and into the morning of the 4th. While not the most spectacular of showers, this year's display should be worthwhile because there will be no bright Moon to wash it out. Look to the northeast to find the constellation of Boötes, the Herdsman, near the Plough asterism; it's here you will find the radiant, the location in the sky where the meteors originate.

There are planets-a-plenty throughout 2022 and in February, Uranus – the seventh planet from the Sun – will be visible in the night sky above the first-quarter Moon on the seventh day of the month – an easy date to remember! Shining at mag. +5.7, and with the bright waxing Moon in view, you will have to reach for your binoculars to see this icy planet – 10x50 binoculars will do, or a small telescope with an aperture of 3 inches and a magnification of x100.

Venus is the morning 'star' throughout most of the year. Easy to identify because of its exceptionally bright appearance, the planet closest to us forms a dazzling sight with Mars on the morning of 27 February. If you can locate the waning crescent Moon hanging low in the southeast, then look to its left and you will easily see Venus shining brightly above Mars.

The peak of the Quadrantids has a ZHR (zenithal hourly rate) of 120 meteors

Venus is at its best and brightest in the early mornings throughout the first half of March – and worth getting out of bed for. The Sun starts rising earlier now and it will soon be time to wave goodbye to those long winter observing sessions that astronomers thrive on. The spring equinox on 20 March marks the beginning of astronomical spring in the Northern Hemisphere. A week later, on 27 March, British Summer Time (BST) begins so remember to put your clocks forward; the morning will now have one hour less of daylight and the evening one hour more. ▸



Venus and Mars will make a beautiful grouping with the waning crescent Moon in February

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Captivating comets

We look forward to a selection of the best icy visitors in 2022


The spectacular naked-eye views of Comet NEOWISE in 2020 showed how impressive comets can be

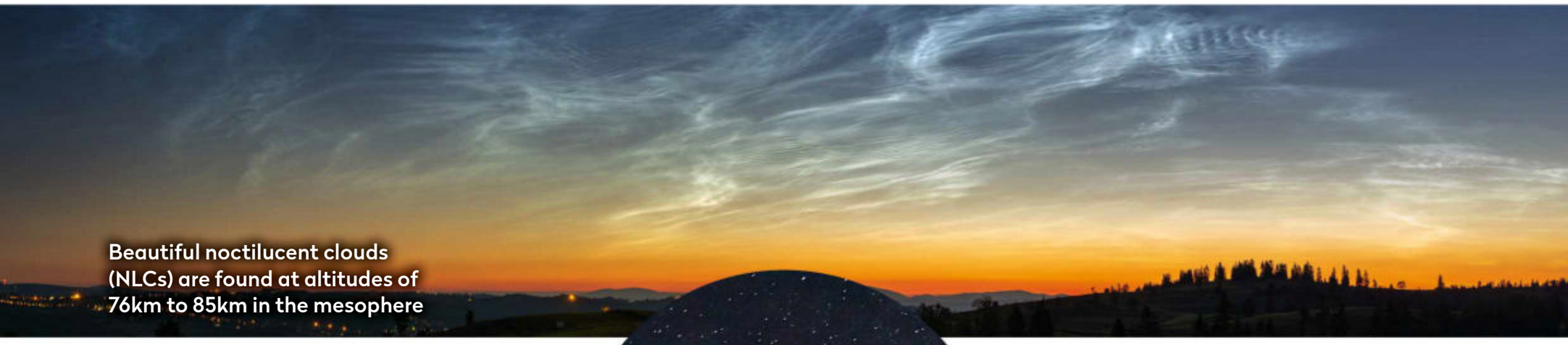
The delight of seeing Comet NEOWISE proved there is nothing quite like seeing a naked-eye comet. But, as we look forward to observing 2022's best comets, remember just how unpredictable they can be.

C/2021 A1 Leonard reaches perihelion in January 2022, but it makes its closest approach to Earth on 12 December 2021, A1 Leonard may become a naked-eye comet, although it will be best seen through binoculars. Locate Arcturus (Alpha (α) Boötis) in the constellation of Boötes, the Herdsman, before sunrise and after sunset to observe.

67P Churyumov-Gerasimenko, 4P/Faye and **C/2019 L3 Atlas** have been visible throughout the past year and can be found located around the constellation of Gemini, the Twins, at the end of 2021. They will be fading but a telescope will enhance your observations.

On 20 January, **Comet 19P/Borrelly** will be at its brightest, around 8th magnitude. Use binoculars or a telescope to see it in the evening in the south by Theta (θ) Ceti in Cetus, the Sea Monster.

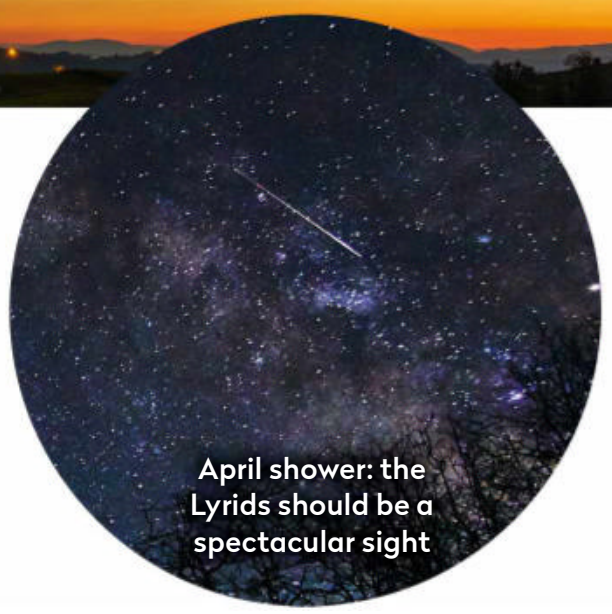
C/2021 O3 (PanSTARRS) reaches perihelion around 20–21 April, and assuming it will survive its closest approach to the Sun, we may see the 6th magnitude comet with the naked eye under dark skies, or with binoculars, from late April to May in the evening sky.


Beautiful noctilucent clouds (NLCs) are found at altitudes of 76km to 85km in the mesosphere

April to June

Mercury is the closest planet to orbit the Sun, which means it is quite an elusive target to spot. We only really see it when it appears at its furthest point, either east or west of the Sun. The Solar System's smallest planet puts on its best show of the year appearing above the western horizon not long after sunset on 10 April and it will be visible until the end of the month. You will have to be quick, though, as it doesn't hang around for long. You should see the planet with your naked eye or through binoculars, but remember to keep safe and only use any equipment with lenses once the Sun has fully set.

On 22 April, we have the peak of another meteor shower, the Lyrids. Thanks to the Moon rising after 03.00 BST (02:00 UT), the sky will be favourable and the view should be spectacular. Set up on the night of 21 April and look towards the constellation of Lyra, the Lyre, rising in the northeast after 22:00 BST (21:00 UT) to see these meteors, which are caused by debris from Comet C/1861 G1 Thatcher.


April shower: the Lyrids should be a spectacular sight

You don't have to wait long for the next meteor shower, but this one will take more effort to see. On the morning of 6 May, the Eta Aquariids will produce around one meteor per minute, but the shower will only be visible for a few hours because the position of its radiant is close to the horizon. If you saw Halley's Comet in 1986 then you will be intrigued to know that these meteors originate from material left behind by that object. Find a location with a clear horizon and look to the east from around 03.30 BST (02:30 UT) until sunrise. Locate the constellation of Aquarius, the Water-Bearer, and enjoy the show!

If you are on social media and a member of an astronomical group, you will be aware of the excitement when the season of noctilucent clouds (NLCs) begins. You won't need any equipment to see this ethereal silvery blue phenomenon. NLCs will only appear on a clear summer's night; they are cirrus-like clouds of ice that are in the mesosphere. Due to their height, they are illuminated by the Sun after it has sunk below the local horizon. Look to the northern horizon in twilight to spot these beautiful clouds.

A rising supermoon can make a wonderful photo opportunity, like this image taken at Glastonbury in 2015

July to September

The year ahead brings two 'supermoons'. If you are unfamiliar with the term, a supermoon, or perigee Moon, refers to a full Moon that occurs around the closest point in its orbit to Earth – for example, around 357,264km away on 13 July. On this date we can look forward to a supermoon that will be 30 per cent brighter than usual and appear 14 per cent larger. If you plan on looking at it through a telescope, then make sure you use a Moon filter to reduce the bright glare; it'll make viewing our natural naighbour much more pleasurable.

The eagerly awaited Perseid meteor shower reaches its maximum on the 12–13 August, when between 100–150 meteors can be seen per hour. This is normally a highlight for keen stargazers, but sadly this year the shower will be washed out by a bright Moon one day past its full phase. Don't be disheartened; it is still worth getting outside to try and catch a glimpse of some of the brighter meteors, and of course to look at the Moon!

In September the planets will delight observers, including a rare occultation of the Moon and Uranus on the 14th. In simple terms, an occultation is when one object passes in front of another, obscuring it from view. the lunar occultation will take place around 22.30 BST (21:30 UT). Expect the event to take around 50 minutes, when Uranus disappears behind the Moon and then reappears. A pair of binoculars or a telescope will be needed because 77 per cent of the Moon will still be illuminated. If you miss this event, read on: you will have a second chance in December!

October to December

Look out for the partial solar eclipse on 25 October

As the nights draw in once more, astronomers will await the longer observing sessions ahead. October brings the Orionid meteor shower, which takes place on the night of the 21st and morning of the 22nd. To locate the radiant, look for Orion, the Hunter, as it rises in the east after 22.00 BST (21:00 UT). Meanwhile, the Taurid meteor shower, also know as the 'Halloween Fireballs', is visible from the end of October to the start of December.

You may have experienced a solar or lunar eclipse, partial or full, but if you haven't, you will get a chance on 25 October when the UK will witness a partial solar eclipse. The Moon will creep across the Sun around 10.00 BST (09:00 UT), obscuring it by about 15 per cent and then vanishing from view at 11.45 BST (10:45 UT). Get some eclipse glasses now!

Over the next two months, Uranus hits the astronomical headlines again. On 9 November it will be at opposition, when it lies opposite the Sun and is at its closest to Earth. Use binoculars or a telescope to observe the bright planet in Aries.

On 5 December we are treated to a second occultation of the Moon and Uranus. Lasting about half an hour, from 16:50 UT to 17:20 UT, the Moon will hide the planet from view just as it did back in September, so get your binoculars and telescopes ready. But that's not all for occultations, as it's Mars's turn to disappear behind the Moon on 8 December at 04:57 UT, reappearing at 05:58 UT.

On 8 December there will be a lunar occultation of Mars at 04:57 UT

On 21 December we celebrate the winter solstice when the Northern Hemisphere is at its maximum tilt away from the Sun, and our nearest star will be at its lowest daily maximum elevation in the sky. As the Sun sets on Christmas day, a thin sliver of the Moon will be visible with Venus and Mercury hanging low in the southwestern sky – making a perfect and peaceful end to the year.

The upcoming year promises to be one of the most exciting in recent times for space exploration, as a host of missions plan to leave our planet

2022 Forging ahead in SCIENCE AND SPACEFLIGHT

From exploring the surfaces of the Moon and Mars to mapping the dark Universe, 2022 is set to be a big year for space science. Ezzy Pearson looks at the projects that will revolutionise our understanding of the cosmos

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University

Race for the Moon

After decades of ignoring our nearest celestial neighbour, nations are now rushing to return to the Moon

Since the Apollo and Soviet missions of the 1960s and 1970s, the Moon has been largely overlooked by space explorers. But that is about to change as dozens of nations and even private companies are set to visit our nearest neighbour in 2022.

The biggest of these is the Artemis I mission, the first stage of NASA's endeavour to return to the Moon with a female moonwalker. Artemis I will be uncrewed, acting as a test for both the Orion crew capsule that will carry astronauts into lunar orbit and the Saturn V-sized Space Launch System (SLS) that will propel them there. The launch assembly is already fully 'stacked' and, once cleared for flight, could be on its way skywards as soon as 12 February. If all goes to plan, the Orion module will take the same flight path as the future crewed missions to the Moon and then spend several days in lunar orbit, before returning to splashdown in the Pacific Ocean.

While Artemis I is paving the way for human landings, robotic landers are leaping on ahead, with missions from all over the globe set to land, rove and even scuttle across the Moon's surface this year. Most are heading towards the southern pole, drawn by the water ice hiding in the shadowed corners of craters there, which makes the region a leading candidate for a long-term lunar base.

Of those attempting to land, Russia undoubtably has the most experience, with eight successful lunar landings under its belt. Although the last of these, Luna 24, was in 1976 they are picking up where they left off, nominally at least, and Luna 25 is due to launch in July. The lander is due to take a sample of lunar soil, known as regolith, and return it to Earth.

In the second half of the year, the Indian Space Research Organisation (ISRO) will be making a second lunar landing attempt with Chandrayaan-3, a rerun of the mission which crashed on approach

▲ Artemis I, now fully 'stacked', puts NASA firmly on track to return to the Moon

on 22 July 2019 due to a software glitch. Provided ISRO achieves a successful landing, the Vikram rover will be released onto the surface, and together the two will explore the lunar pole's environment.

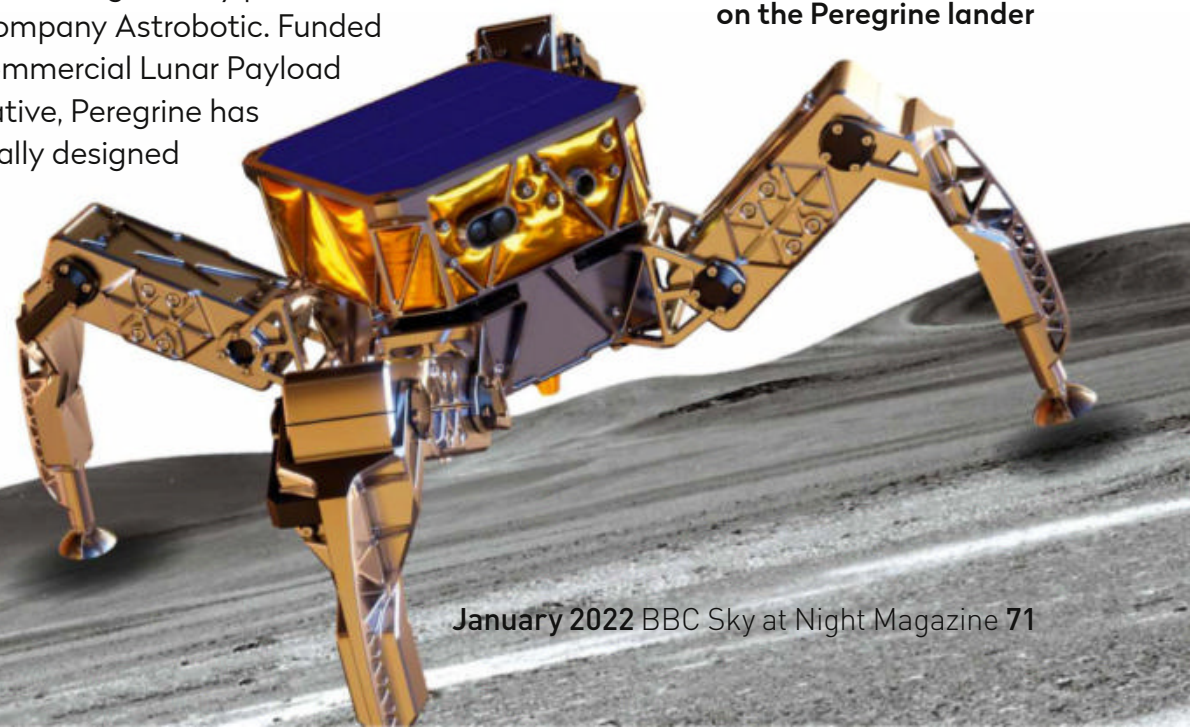
Vikram won't be the only rover heading to the Moon, however, thanks to the Peregrine lander being built by private spaceflight company Astrobotic. Funded by NASA's Commercial Lunar Payload Services initiative, Peregrine has been specifically designed as a platform to carry all manner of payloads to the surface. Though the landing platform has never been tested in space, there are plenty of organisations that are willing to hitch a ride. As well as 14 NASA instruments, the lander will have six rovers, including the spider-like Asagumo walking rover (pictured, below) from the UK-based company Spacebit. Once it has proven itself, NASA plans on using the Peregrine lander to carry the much larger Volatiles Investigation Polar Exploration Rover (VIPER) in 2023, which will investigate water in the polar region.

Not everyone is aiming for the lunar south pole, however. The Japan Aerospace Exploration Agency's Smart Lander for Investigating Moon (SLIM), is instead heading for the Marius Hills Hole, a lava tube near the Moon's equator. The mission will aim for a landing area just 100m wide, using the same software used in facial recognition to attain the most precise landing ever made.

Finally, South Korea will be make its first foray into planetary exploration in August with the Korean Pathfinder Lunar Orbiter, in collaboration with NASA. The orbiter will examine the mineral composition of the Moon and its varied volcanic deposits.

Fifty years after the Apollo missions, it looks like the Moon is firmly back on the top of every space agencies' priority list. ▸

▼ A spider from Mars? The Asagumo rover will be transported to Mars on the Peregrine lander



DARTLAB/ISTOCK/GETTY IMAGES, ADOBEBOX/ISTOCK/GETTY IMAGES, NASA/FRANK MICHAUX, ©2021 SPACEBIT TECHNOLOGIES

The DART spacecraft will be deliberately crashed into a space rock to alter its orbit...

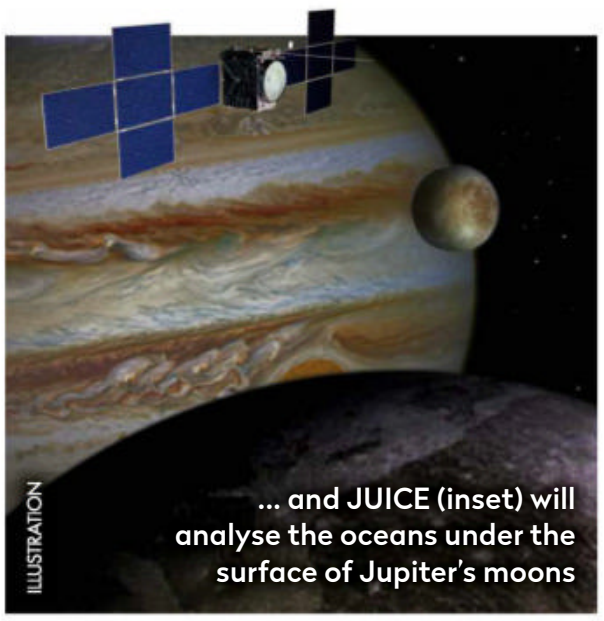
ILLUSTRATION

Small worlds

Moons and asteroids could help us understand the origin of our Solar System

ESA's Jupiter Icy Moons Explorer (JUICE) is due to launch in May 2022 and arrive at Jupiter seven years later. Once there, it will turn is gaze towards the frigid worlds of Europa, Ganymede and Callisto. Skimming past them around 30 times, it will examine their gravity and magnetic fields to reveal the oceans under the ice, which may be the most likely place to find extraterrestrial life in our Solar System.

Then in August, NASA's Psyche mission will head for the metal-rich asteroid that gives the mission its name. Asteroids are the remnants of would-be planets that were destroyed early in the Solar System's history, and metal asteroids are believed to have originated in the cores of these planets, meaning geologists can finally investigate part of a planet usually hidden beneath thousands of kilometres of rock.



ILLUSTRATION

... and JUICE (inset) will analyse the oceans under the surface of Jupiter's moons

The most dramatic event, however, is due on 2 October when NASA's Double Asteroid Redirect Test (DART) will slam into the moon of asteroid Didymos. The collision should change the moon's orbit – a test of technology that could one day be used to deflect a much larger asteroid from colliding with Earth.

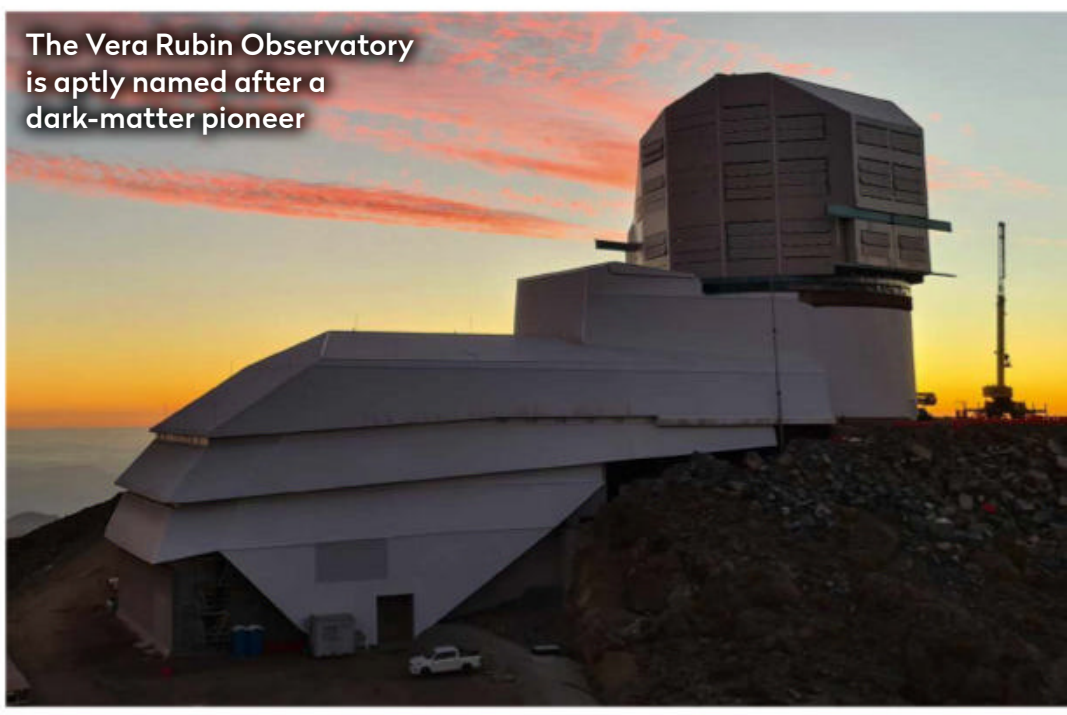
Shining a light on the dark Universe

The Vera Rubin Observatory will help map the unseen cosmos

The dark side of the Universe is due for a little illumination as the Vera Rubin Observatory in Chile is set to see first light this year, ahead of going into full operation in 2023. The telescope will use its 8.4m-wide mirror to image 18,000 square degrees of sky – almost half of the celestial sphere – over 800 times. The goal of this momentous observing campaign is to map the distribution of mysterious dark matter threading throughout the Universe, and understand the even more enigmatic dark energy driving it apart.

The observatory will be able to get such a refined level of detail, even on distant galaxies, that astronomers can look for an effect known as weak gravitational lensing, where the light from distant galaxies is bent as it passes by large masses. As most of this mass is dark matter, these lenses can reveal the distribution of the otherwise invisible substance.

Vera Rubin will also help our understanding of dark energy, a theoretical force which forces galaxies apart, by helping to measure how fast the Universe has been expanding over time.



The Vera Rubin Observatory is aptly named after a dark-matter pioneer

NASA/JOHNS HOPKINS APL, NASA/JPL/UNIVERSITY OF ARIZONA/DLR NASA/JOHNS HOPKINS APL, RUBIN OBS/NSF/AURA, NASA, ©HIE 2021, ESA/ATG MEDIALAB

Boeing's Starliner crew capsule on the way to the launch pad in October 2021

Another step for human spaceflight

New crew modules and a finished space station are a different

The year 2021 was a turning point for private human spaceflight, with both Virgin Galactic and Blue Origin launching space tourists for the first time. But after a year of troubles, Boeing is hoping 2022 will be its year. Its issues began in December 2019 when the first uncrewed test of its Starliner crew capsule (above) failed to reach the International Space Station. Then a repeat attempt in August was called off at the last minute when some fuel valves failed to open. Boeing plans to launch in the first half of 2022, paving the way for a crewed test later in the year.

Elsewhere, the Chinese space agency will finish the construction of its space station, adding the Wentian and Mengtian lab modules. And finally, the Indian Space Research Organisation (ISRO) will take the first steps in creating its own human spaceflight programme, with the inaugural flight of its Gaganyaan 1 crew module. Though this test will be uncrewed, the ISRO hopes to carry its first 'vyomanauts' into orbit as soon as 2023 and ultimately build its own space station.

The Great British Space Race

The first space launch from British soil could happen this year

Sutherland spaceport is on track to open in 2022

ILLUSTRATION

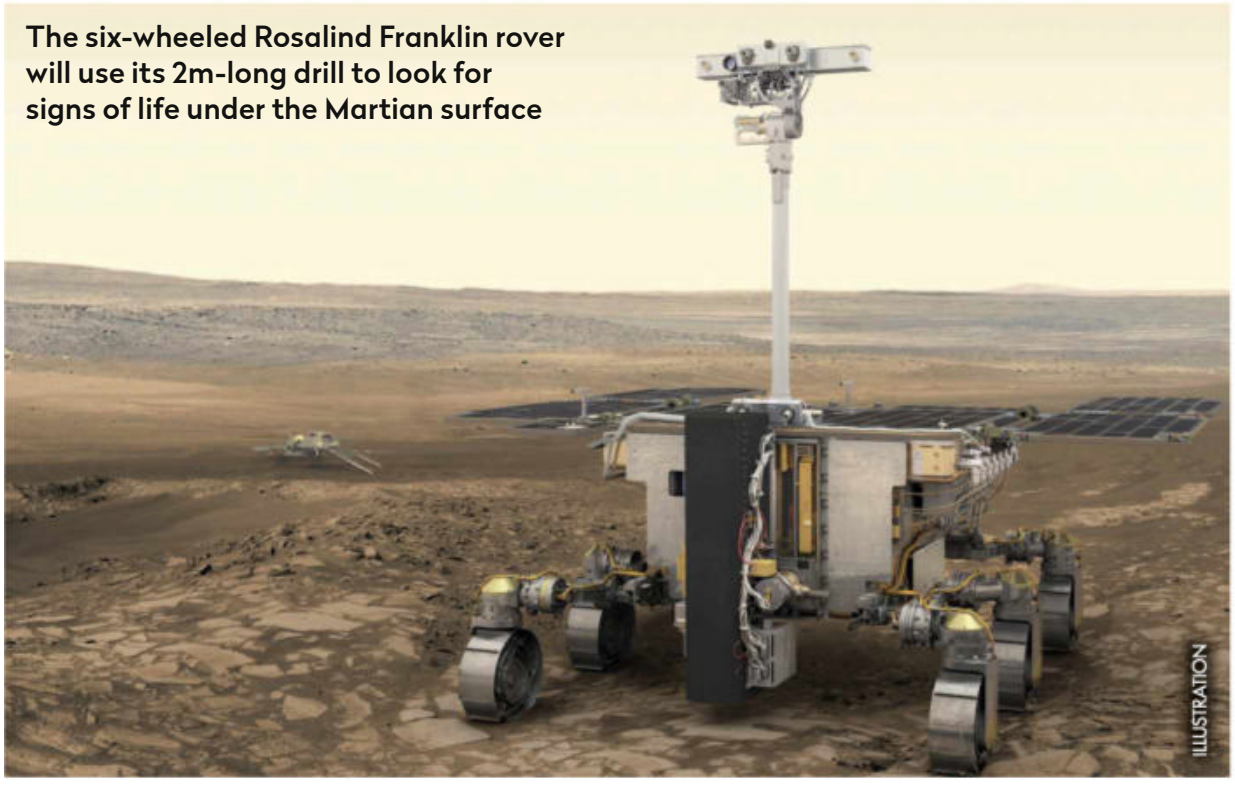
Last summer, the first licenses for rocket launches from UK soil were given, meaning 2022 looks set to be the start of the 'Great British Space Race' as spaceports compete to launch first.

Spaceport Cornwall, based at Newquay airport, is the UK's only horizontal spaceport, meaning traditional planes are used for the first section of the ascent. The first launch from the port is likely to be Kernow Sat 1, a Cornwall-designed Earth observation satellite that will launched by Virgin Orbit.

Meanwhile, the SaxaVord Spaceport on Unst in the Shetland Isles hopes to launch the first of the UK Space Agency's Vertical Launch Pathfinder Programme. And another Scottish spaceport, based in Sutherland, is commencing construction with a goal of launching by the end of 2022.

Rosalind Franklin rover heads to Red Planet

The rover will investigate the past habitability of Mars



The six-wheeled Rosalind Franklin rover will use its 2m-long drill to look for signs of life under the Martian surface

ILLUSTRATION

September will see the launch of the Rosalind Franklin rover towards Mars. The rover was supposed to lift off in 2020, but problems with its parachutes pushed the schedule back by a few months, meaning it missed its launch window. Now, 26 months later, Mars and Earth will align once again and it can start its journey.

The mission is a joint endeavour between the European Space Agency and the Russian space agency Roscosmos, and will hunt out the signs of past Martian life. The rover's biggest asset is a 2m-long drill that can reach deep down under the weather- and radiation-ravaged surface to where signs of past life might survive. The onboard instruments will then be able to analyse the soil's mineral composition, hunting out organic material, as these are the building blocks of life.

There is an air of trepidation surrounding the endeavour, however, as neither Europe nor Russia has had much luck landing on Mars in the past. Of the 19 Russian and Soviet missions and two European attempts to land – including the Schiaparelli lander in 2016, intended to be a trial run of this landing – none have been fully successful. Hopefully, the agencies have learned from their mistakes to ensure Rosalind Franklin's success.

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Build a roll-off roof garden observatory

PART 3 OF 3

Install a low-voltage electrical system and make your setup solar powered

Ready to go: the completed telescope setup with the control boxes and solar panels installed

This final part of our series covers how to take a roll-off roof (ROR) observatory 'off grid' with solar power, and make a power distribution box for the equipment inside.

By using solar power we can keep everything to a nominal 12V, so there is no electric shock hazard, but there is still the potential for an electrical short circuit to cause overheating and a possible fire. Always have your circuitry checked by a qualified electrician.

To begin, check the power or current requirements of your mount, cameras, dew heaters, and any other accessories, and make a realistic estimation of how long they will be used; our estimation was for up to three (five-hour) sessions per week. Next, calculate the size of the solar panels. Begin by assuming that the panels will supply a maximum of 80 per cent of the stated power, and take into account the effect of their orientation (visit **bit.ly/30A2heP** for details).

We mounted our solar panels nearly flat to reduce their exposure to the wind (windage); this reduces their output to 84 per cent of what it would have been at the optimal orientation of 30–40° to the horizontal, facing due south. You must also allow for your longest nights, when the daytime – solar charging time – and the Sun's strength, are at their least. The daily intake of the Sun's energy (insolation) at 53°N ranges from 7kWh/m^2 in midsummer to just 10 per cent of this in midwinter (visit **bit.ly/30DXeJX** for more details). We worked on the assumption that if we had three observing nights per week, we could expect three sunny days as well. Now decide how many 'extra' sessions you need your battery to store, and work out the battery size. You'll need a deep-cycle SLA (sealed lead-acid), Li-ion or LiFePO4 battery.

We built our power distribution board into a weatherproof junction box. Each circuit can be independently switched on and off and is fused via a six-way fuse box. It has the following outputs: a 12V nominal unregulated output for the dew heaters, and two 12V regulated circuits for the mount, cameras and other equipment. The battery voltage can sometimes exceed 14V, which could damage 12V circuitry, hence the regulated output. We used GX-12 condensation-proof sockets for these outputs. There are also two USB sockets for peripherals, plus red lights (car LED marker lights) and a white (number plate) light.

The observatory equipment is controlled by a Raspberry Pi single-board computer running StellarMate software (**www.stellarmate.com**), which communicates over Wi-Fi with a desktop computer. Along with KStars astronomy freeware (**edu.kde.org/kstars**) and its integrated Ekos astrophotography suite, this setup enables you to remote control your scope and cameras; a separate project to cover later.

Once your roll-off roof observatory is complete, you have a functional, independently powered observing location to enjoy the clear night skies, be it for viewing or imaging pleasure.

Steve Tonkin is a binocular observer who takes part in projects with The Astronomical Unit

What you'll need

- Solar panels; a solar panel mounting kit; MC4 connectors and branch connectors; an MC4 crimping tool; a 12V deep-cycle battery; an MPPT (multi power point tracking) charge controller; insulated cable, circuit breakers and line fuses; a six-way fuse box and a Mini Busbar.
- Sundry connectors, plugs, sockets and switches; an earth spike and cable; red LED marker lights and an LED number plate light; a dual USB car socket.
- A weatherproof junction box; bituminous tape, cable entry housing; sundry screws, nuts, washers and bolts; cable clips.

ALL PICTURES: STEVE TONKIN

Step by step

Step 1

Attach the mountings to the solar panel, put it in place, mark the positions of the mounting holes, and drill through the EPDM (ethylene propylene diene terpolymer) rubber membrane into the joists. Add patches of bituminous tape between the mountings and the EPDM and secure the mountings with lag bolts.

Step 2

Next, you should put a circuit breaker and fuse between the solar panels and the charge controller, as well as between the charge controller and the battery. Look at the charge controller documentation from the supplier, as this will tell you what size fuse and cable you should use in each part of the circuit.

Step 3

Wire in the panels using the weatherproof MC-4 connectors, ensuring that they are properly locked. It is advised to have them underneath a solar panel and suspended off the roof surface. The solar panel frames should be grounded to an earth spike.

Step 4

Follow the manufacturer's instructions and, after ensuring that the circuit breakers are open, connect the charge controller to the battery and the solar panels. We used an MPPT controller, as it is more efficient and cheaper than the PWM variety.

Step 5

Check the circuitry with a meter, ensuring there is no short circuits. Close the battery circuit breaker and set the battery type on the controller. Then close the solar panel circuit breaker and wait for confirmation that your panel is charging the battery.

Step 6

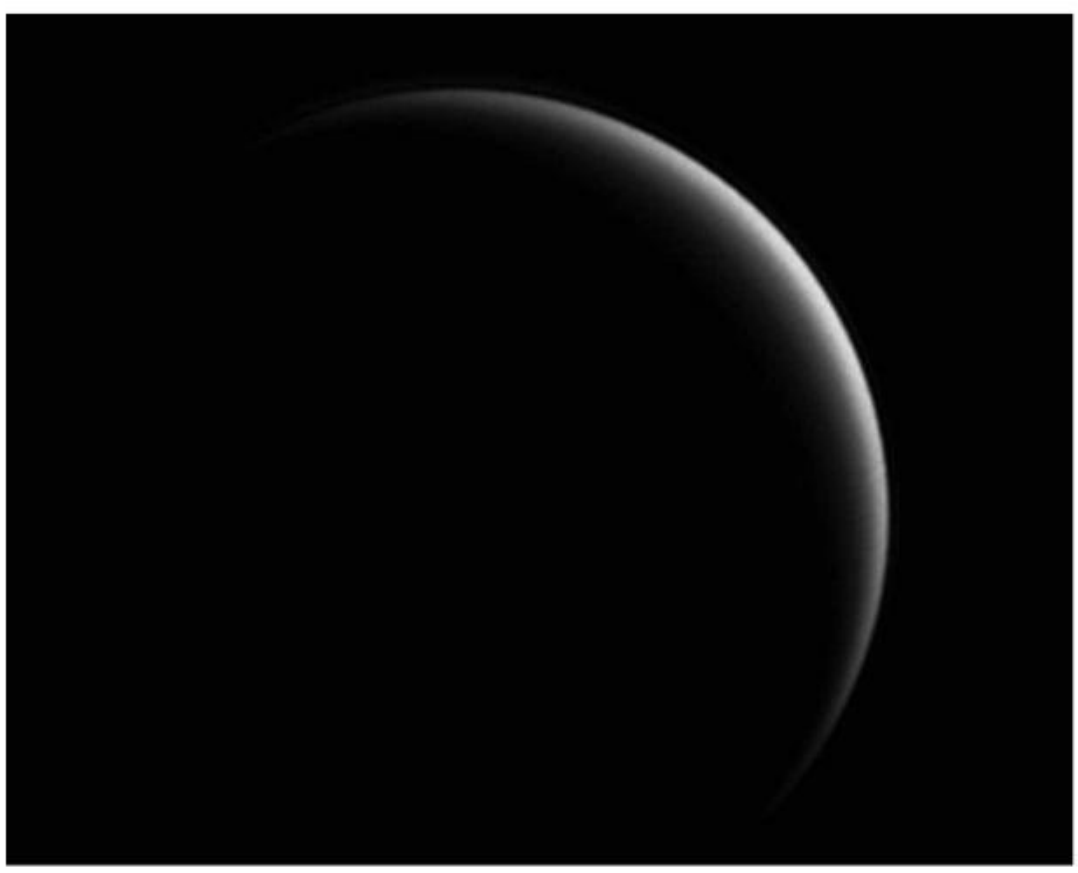
Connect your distribution box, via a fuse and SAE connector, to the load output of the charge controller. Then switch the distribution box on and check the output from each of the circuits within the box.

If all is well, you will be able to connect your telescope, cameras, dew heaters etc, and you are ready to go!

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Imaging the crescent of Venus

How to safely capture the planet's slender crescent around inferior conjunction



▲ **Imaging the elegant crescent of our planetary neighbour must be approached with care, due to its close proximity to the Sun**

Venus reaches inferior conjunction on 9 January, a time when it lines up with the Sun in the sky on the part of its orbit nearest to Earth. This is an exciting time for Venus watchers as, during the evening approach to inferior conjunction and morning exit from it, Venus appears as a slender crescent. There are safety considerations here: viewing Venus as a crescent means it's going to appear close to the Sun. So follow all the solar safety measures and never view the Sun with the naked eye or unfiltered optical equipment.

On 1 January, Venus appears separated from the Sun by 12°, setting 75 minutes after the Sun below the southwest horizon. The apparent separation in degrees and the setting time decreases in the days that follow; the planet will probably be lost from general view during the middle of the first week of January.

If you have experience of viewing the planet during the day when the Sun is up, it will still be possible to see it at this time and probably through inferior conjunction, but as Venus passes 4.8° north of the Sun when it reaches this position, viewing it at this time should only be attempted if you know what you are doing. At this apparent separation from the Sun, there is a risk of injuring your eyes or damaging equipment.

Re-emergence from inferior conjunction into the morning sky is rapid and for those with a flat southeast horizon, the planet may be seen before sunrise from 14 January, rising an hour before the Sun.

An object of beauty

A telescopic view of Venus in January will show its beautiful crescent phase and the planet's brilliance makes it ideal for imaging. The low altitude, however, will play havoc with the finesse of the crescent, wobbling the sharp cusps and rendering them blurry.

This can be offset by imaging during the day. Although the altitude of the planet never gets high, a little higher does make a difference. Also, the effects of temperature gradients are less severe in the day.

A high frame rate camera fitted to a telescope will give the best results, and as you're going to be imaging through blue sky during the day, it's recommended to fit an infrared pass filter to the camera's front. This has two benefits; firstly, it will darken the surrounding blue sky to black and second, it will reduce the effects of atmospheric turbulence.

Locating Venus in daylight carries a danger with it due to the proximity of the Sun. If your mount has setting circles, these are a great help. If you're not sure what you're doing, attempt to image when Venus is either in the morning sky before sunrise, or in the evening after sunset. Whichever method you use, it's well worth capturing the Venusian crescent.

Recommended equipment: Telescope fitted with a high frame-rate camera; polar-aligned tracking mount with setting circles

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

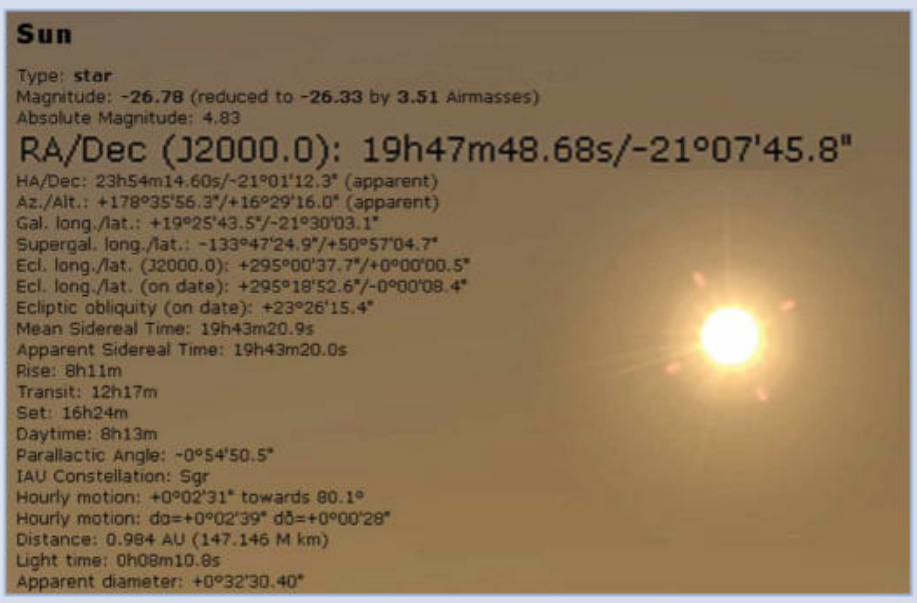
Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

STEP 1

Use a camera setup that gives a 0.5–1.0°-width field of view. With the scope mounted and pointing away from the Sun, fit a full aperture, certified and pre-checked white light filter. Cap, filter or remove any finders and use the scope's shadow to point at the Sun. Tweak the position until the Sun is seen by the camera.

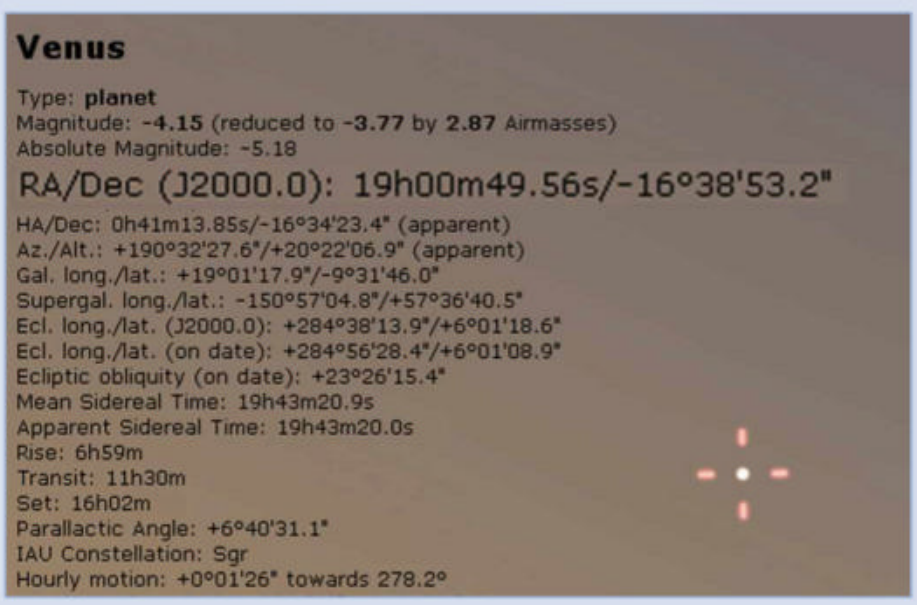


STEP 2

Twist your camera so slewing in RA (Right Ascension) moves the Sun parallel to the screen's bottom edge. Focus on the Sun as accurately as possible. If there are no sunspots, use its limb. Next, centre the Sun's disc on screen. Obtain its current RA and dec. (declination) with a planetarium program such as Stellarium.

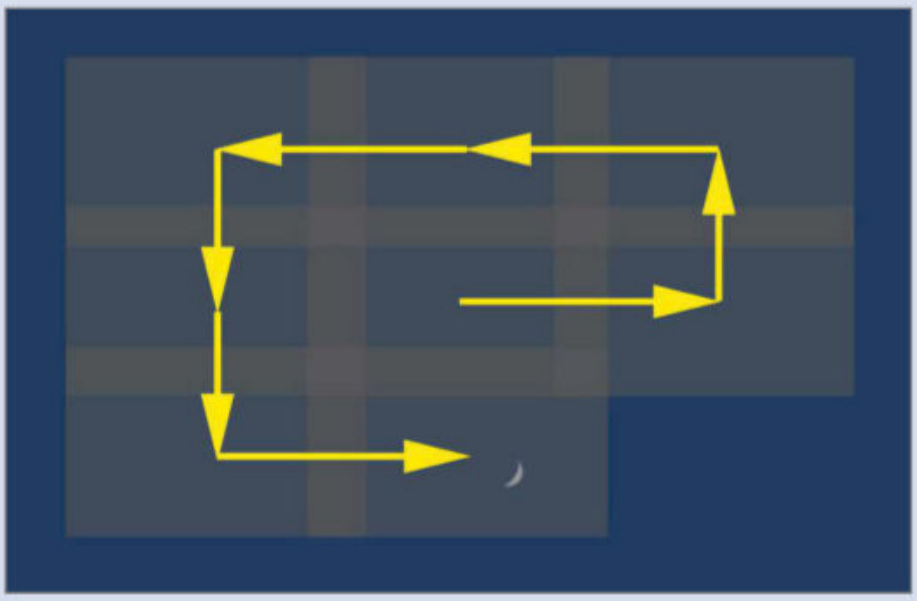
STEP 3

Using your mount's RA setting circle, use the scale which increases in value when you slew east. Unlock the setting circle and rotate it to match the Sun's RA value obtained in Step 2, then lock again. Do the same with the dec. scale, making sure you use the scale which increases in value when you slew north.



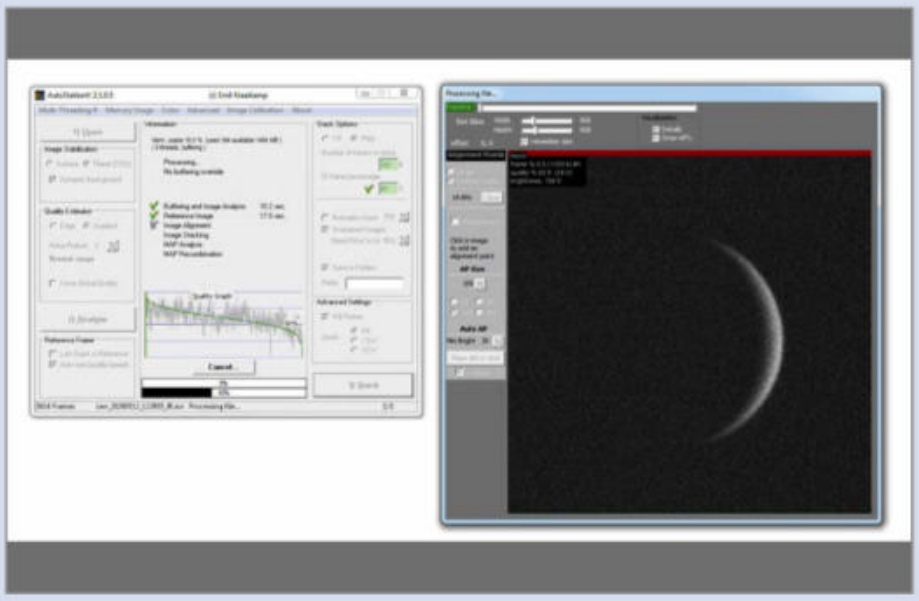
STEP 4

Look up the RA and dec. of Venus. Slew towards Venus in RA until the RA setting circle indicates the correct value. Slew in dec. until that setting circle matches. Early in January, Venus is north and east of the Sun; later in the month, it's north and west. Ensure you're pointing away from the Sun then remove the solar filter.



STEP 5

Venus may appear in frame, but typically you'll need to do a small spiral search of the area, making sure you never point at the Sun. If the search area widens too much, give up and restart from Step 1. Once Venus is centred in the frame, try increasing the image scale with a Barlow lens; this will need re-focusing.



STEP 6

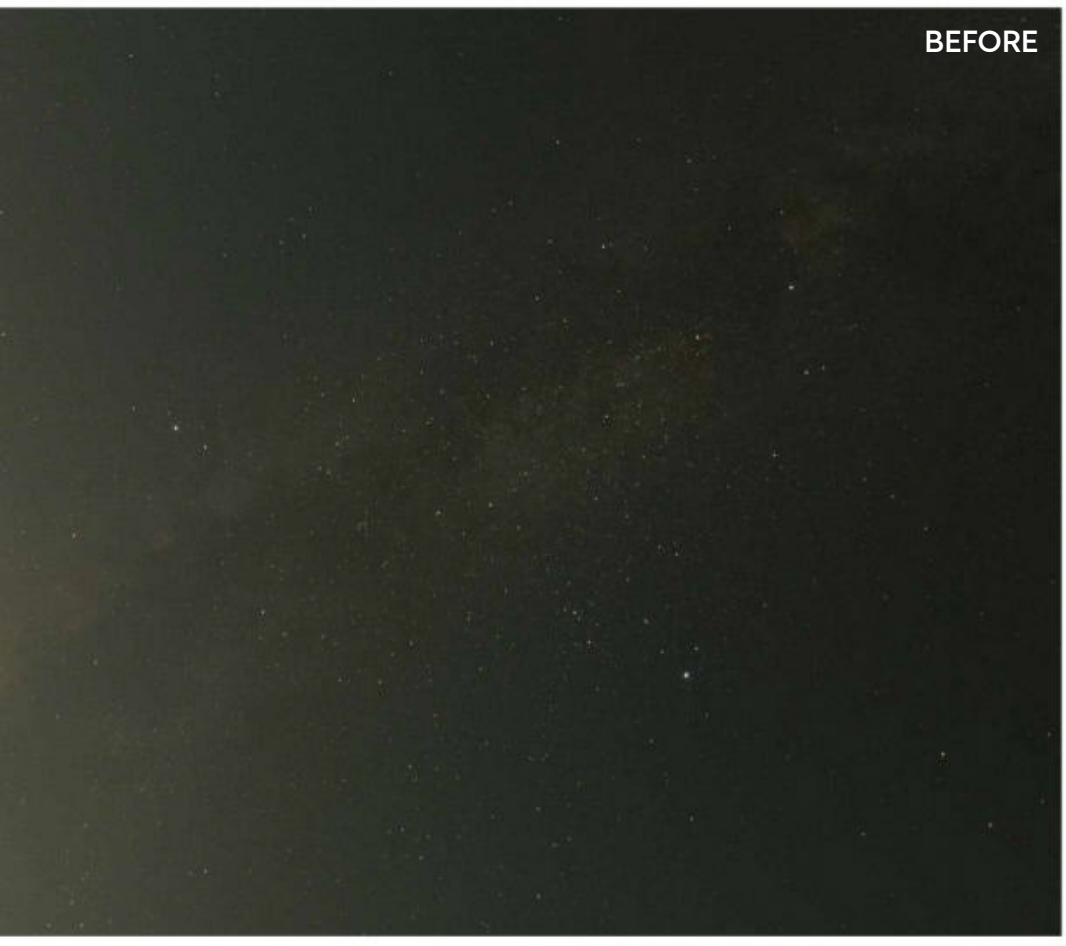
Adjust camera settings to balance a low gain and high frame rate. The use of an IR-pass filter helps to improve contrast. Monitor levels to avoid over-saturation and capture several thousand frames, processing results using a stacking program such as AutoStakkert! Point the telescope away from the Sun.

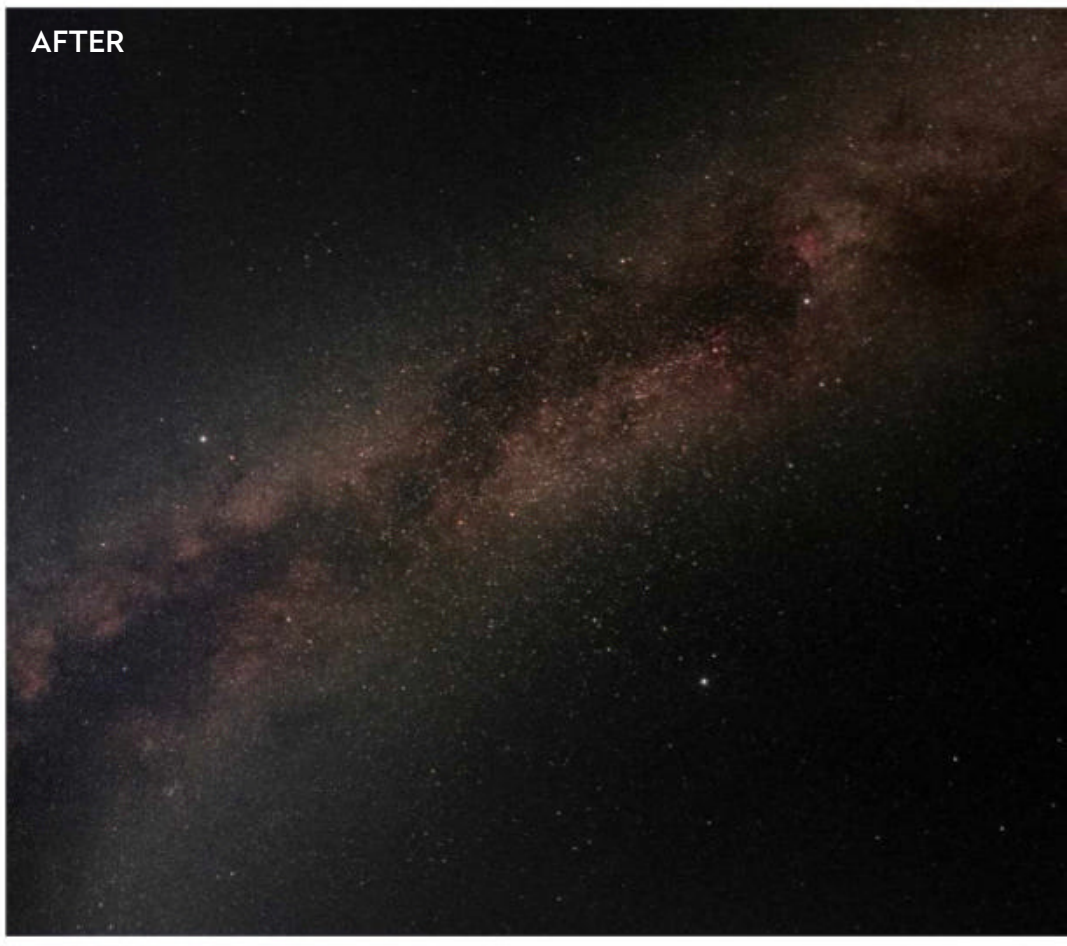
Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

How using layers can enhance a Milky Way image

Use the image-processing function to stack and adjust an image of our home Galaxy





ALL PICTURES: CHARLOTTE DANIELS

An essential part of an astrophotographer's processing toolbox, the 'Layers' function exists in most processing software, including Adobe Photoshop and GIMP. 'Layers' can be used to stack multiple image files; a technique that reduces noise (unwanted artefacts) in the final image. It also allows us to make gradual enhancements to our image files along the way. As the 'Layers' function provides the ability to delete small processing errors at any stage of our edit, it means we don't have to start again if we make a mistake. In this article we will show you how to use the 'Layers' function in Photoshop to stack and process an image of the Milky Way (see the 'before' image, above) to bring out its wonderful, starry detail.

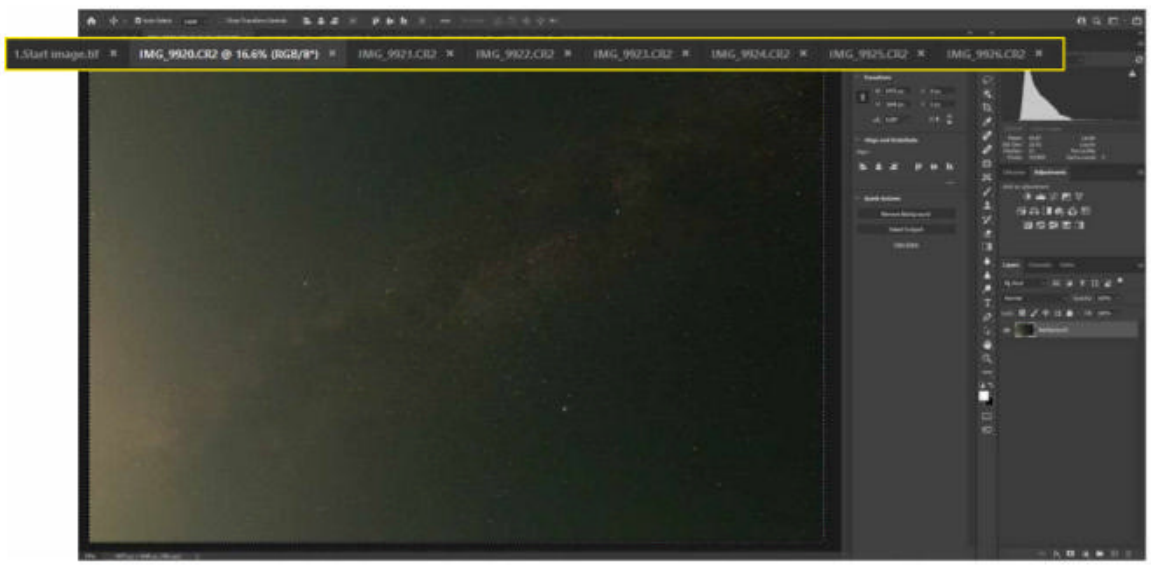
We start by opening the image files that we want to stack in Photoshop. Click 'File > Open' and navigate to the image file location. To open multiple image files in Photoshop, we hold the 'Ctrl' key and select all the required files from the file location, before clicking 'Open'. Photoshop then uploads each of the selected files in separate windows (see Screenshot 1 on the top of the opposite page). Each of these files will be used to form layers within our stacked image. The file on the far left of Screenshot 1 – labelled 'Start image' in our example – will form our base image. We will copy and paste all the other image files onto this one.

▲ Left: Our initial image of the Milky Way is full of unwanted detail, which we will remove in 'Layers'

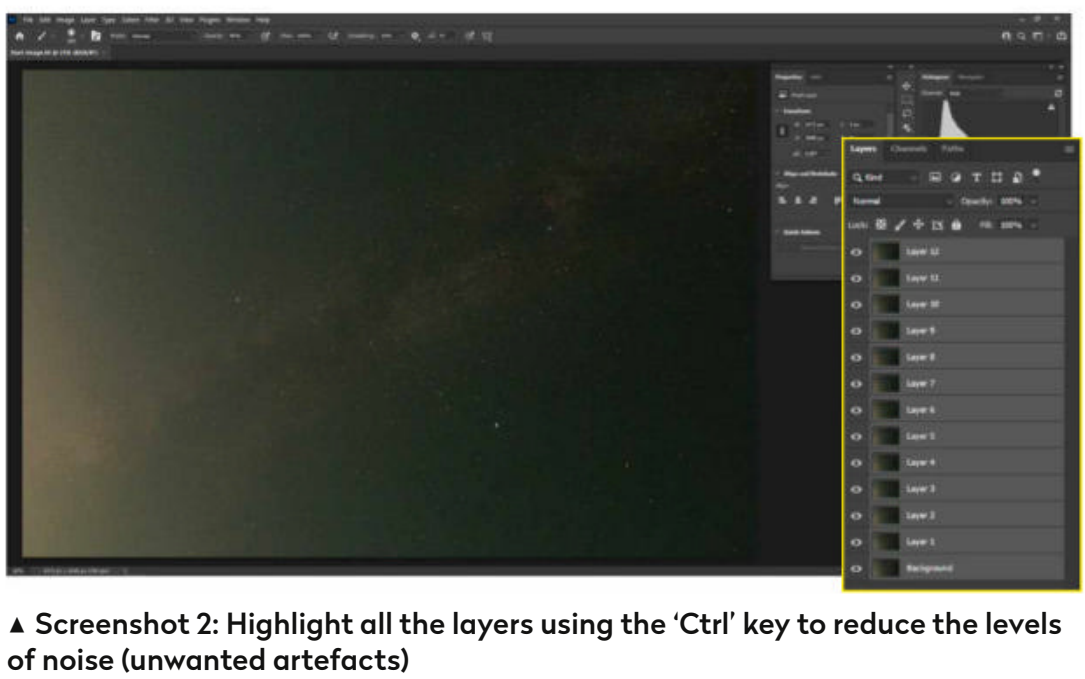
Right: The finished image brings out the detail and outline of the Milky Way as it arches overhead

Getting ready to stack

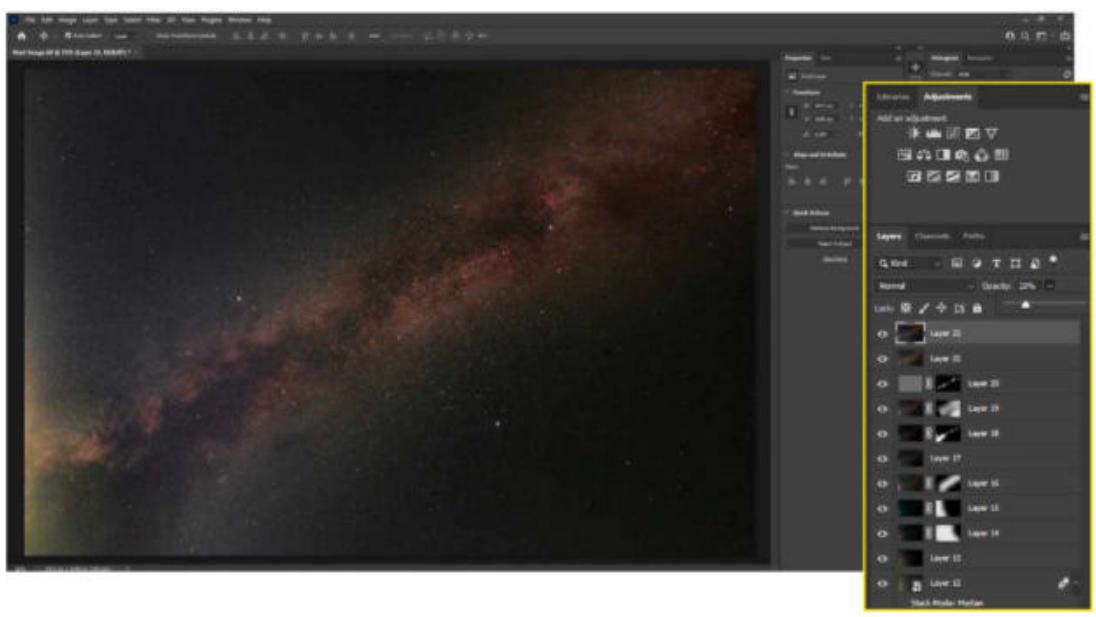
To combine these files into a single image ready for stacking, first start with the file window to the right of the base image – this will become 'Layer 1'. Click on the tab for this image, as highlighted in Screenshot 1, and then press the 'Ctrl and A' keys at the same time. You will now see the image highlighted with dashed lines. Alternatively, you can click 'Select > All' in the image window. By pressing the 'Ctrl and C' keys, this image is copied (or click 'Edit > Copy'). Next, click back on the base image window, and press 'Ctrl and V'.



▲ **Screenshot 1: In Adobe Photoshop we can load our image files in separate windows, ready to become stacked layers**



▲ **Screenshot 2: Highlight all the layers using the 'Ctrl' key to reduce the levels of noise (unwanted artefacts)**



▲ **Screenshot 3: Fine tuning adjustments can be made, including 'Opacity'**

This will place your first layer on top of your base image as 'Layer 1'. You can now delete the window that you copied this file from by clicking the 'X' symbol in the corner of the tab and proceed onto the next image file. Next, repeat the copy and paste steps for all the image files you wish to stack, so that these become layers on top of the base image.

Now we need to merge these layers into a single stacked file – reducing the number of layers to one. To do this, select every layer by holding down the 'Ctrl' key while clicking each layer, so that they are all highlighted (see Screenshot 2). Next, click 'Layer › Smart Objects › Convert to Smart Object'. Once Photoshop has processed this command, click 'Layer › Smart Objects › Stack Mode › Median'. You'll see the image change as the noise level is gradually reduced.

We can now use the 'Layers' function in a slightly different way, to edit this stacked image. The most effective way to use 'Layers' for editing is to create a duplicate of the preceding layer, so that we can use a new layer to make a separate adjustment each time. To do this, hold down the 'Shift, Ctrl, Alt, N and E' keys simultaneously. You will now see a new, identical layer form (see Screenshot 3). You can now select any item from the 'Adjustments' menu – for example, 'Adjusting levels', or 'Brightness/Contrast' – which we have highlighted) and make an alteration specifically to that layer. Once satisfied with the adjustment you've made, use the mouse to right click on the layer and select 'Merge Down'. This will combine your adjustment with the layer.

Easily adjust your edits

By creating a new layer before making a new adjustment, you are separating your process into stages. The advantage of creating these layers for all the key steps, is that you have the flexibility to go back to any point and quickly review all of your steps to see where something might have gone wrong, or to mark what you did right. If you decide an adjustment has made a change that you don't like, you can remove that layer by right-clicking on it with the mouse and selecting 'Delete Layer'. If you feel the adjustment was slightly too aggressive, you can also solve this by adjusting the 'Opacity' for that layer. Just move the 'Opacity' slider (see Screenshot 3) to reduce the effect of the alteration.

To ensure full control of your edit, repeat the above steps on every adjustment you make. When you have finished, you can use the mouse to right-click on a layer and select 'Flatten image'. This ensures the finished image is in a suitable format to export as a JPEG or TIFF file (click 'File › Export as...').

We now have the completed image, where the Milky Way is revealed in all its glory.

Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

3 QUICK TIPS

1. You can change the effect of an adjustment layer by amending the 'Layers' mode; popular types are 'Colour' and 'Luminosity'.

2. Try 'Hide All' and 'Reveal All' masks, where each adjustment layer is applied to the image.

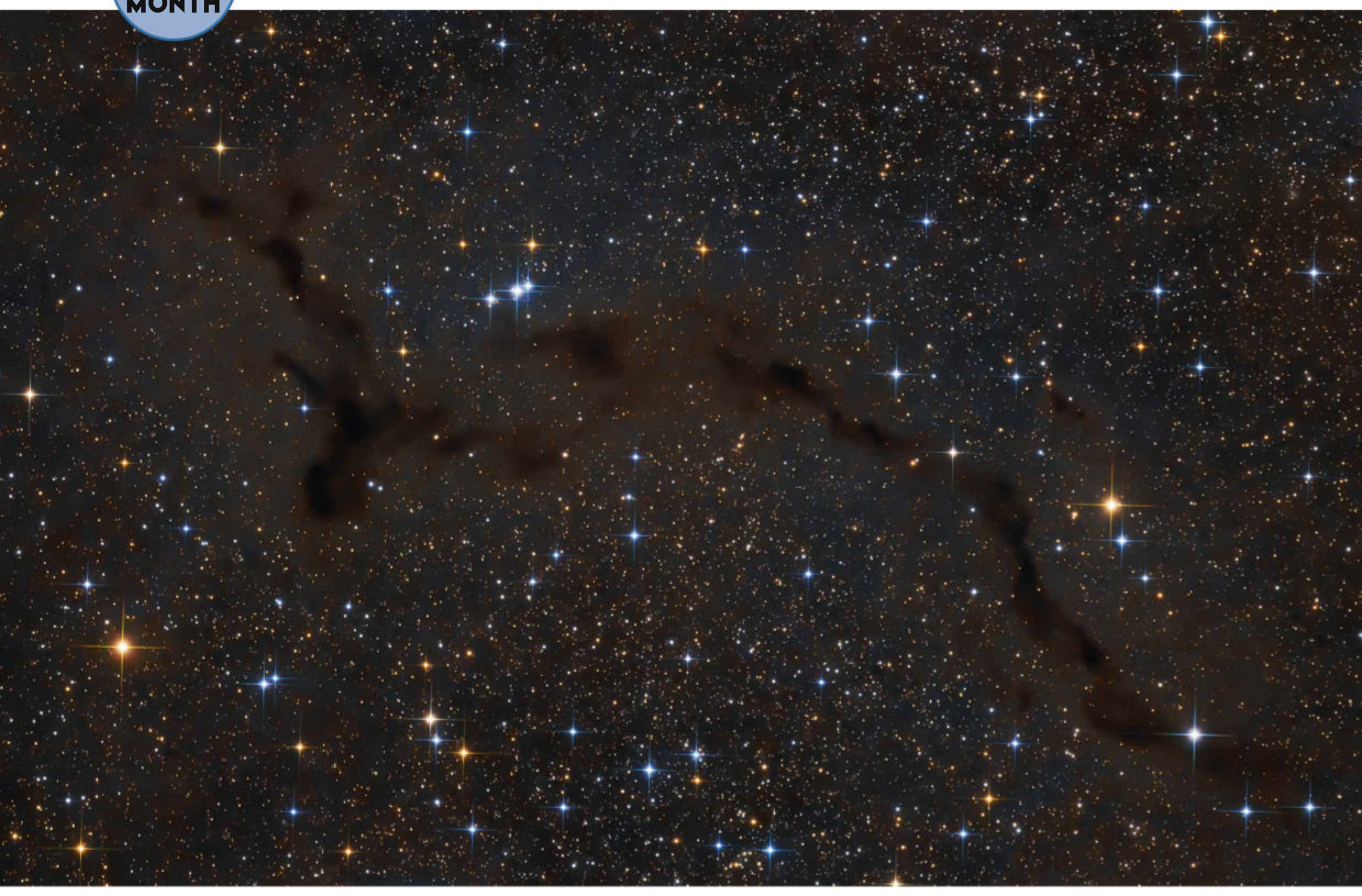
3. Use the 'eye' icon next to each layer to establish whether your most recent layer has improved the astro image before keeping or deleting.

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

PHOTO OF THE MONTH



△ The Seahorse Nebula

Emil Andronic, Bushey, Hertfordshire, 7 September–2 October 2021

Emil says: "This is the dark nebula Barnard 150 in LRGB (Luminance, Red, Green and Blue). Living in London suburbs under Bortle 7 skies has put me off trying to image dark nebulae, but I've been wanting to capture this target for ages and I had to try and see if it was possible."

Equipment: ZWO ASI294MM Pro camera, Astro-Tech AT 106LE triplet apo refractor, Sky-Watcher AZ-EQ6 mount
Exposure: L 100x 180", R 50x 180", G 50x 180", B 50x 180"
Software: SG Pro, Astro Pixel Processor, PixInsight, Photoshop

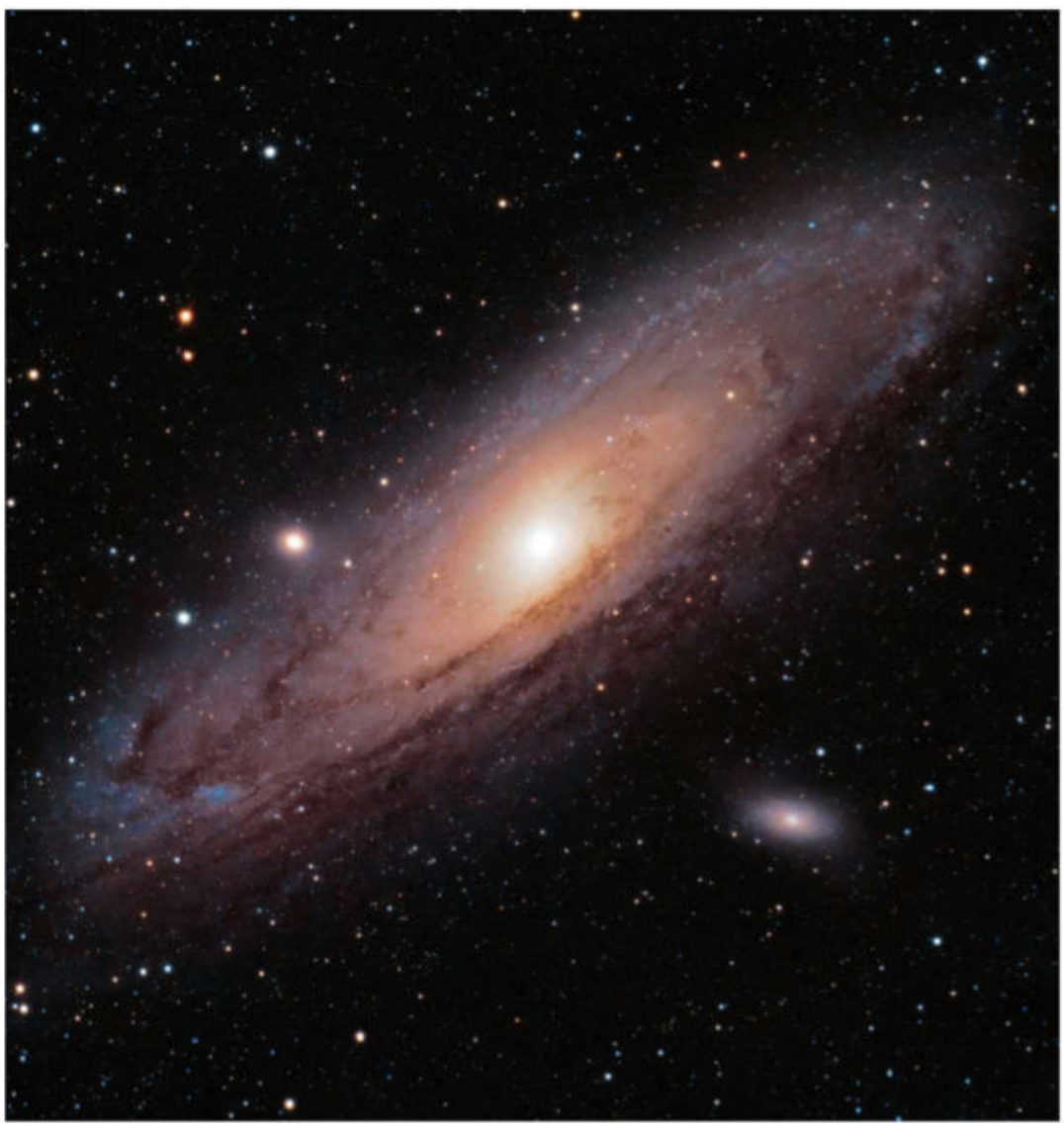
Emil's top tips: "Light pollution is a major issue for me. To combat it, a mono camera has some great advantages. Combined with a light pollution filter instead of a luminance one, you'll get much better contrast and detail for targets like dark nebulae. Wait for the perfect time when the target is at its highest and there's no Moon. Keep the camera gain and exposure time relatively low to stop the sensor being swamped by light, but gather more Luminance (L) data than the Red, Green and Blue (RGB) channels to suppress unwanted noise."

△ The Heart and Soul Nebulae

Martin Bracken, Chelmsford, 25 September–3 November 2021

Martin says: "This six-panel mosaic shows what can be achieved using amateur equipment and narrowband filters even in light-polluted conditions."

Equipment: ZWO ASI294MC Pro camera, Sky-Watcher Esprit 100ED refractor, Sky-Watcher HEQ5 Pro mount **Exposure:** each panel 60x 300" **Software:** NINA, DeepSkyStacker, MS ICE, PixInsight, Photoshop



△ The Pleiades

Matthew Shutter, Tring, Buckinghamshire, 2 November 2021

Matthew says: "I captured this using my new dedicated astro camera. It improves the signal-to-noise ratio of my image."

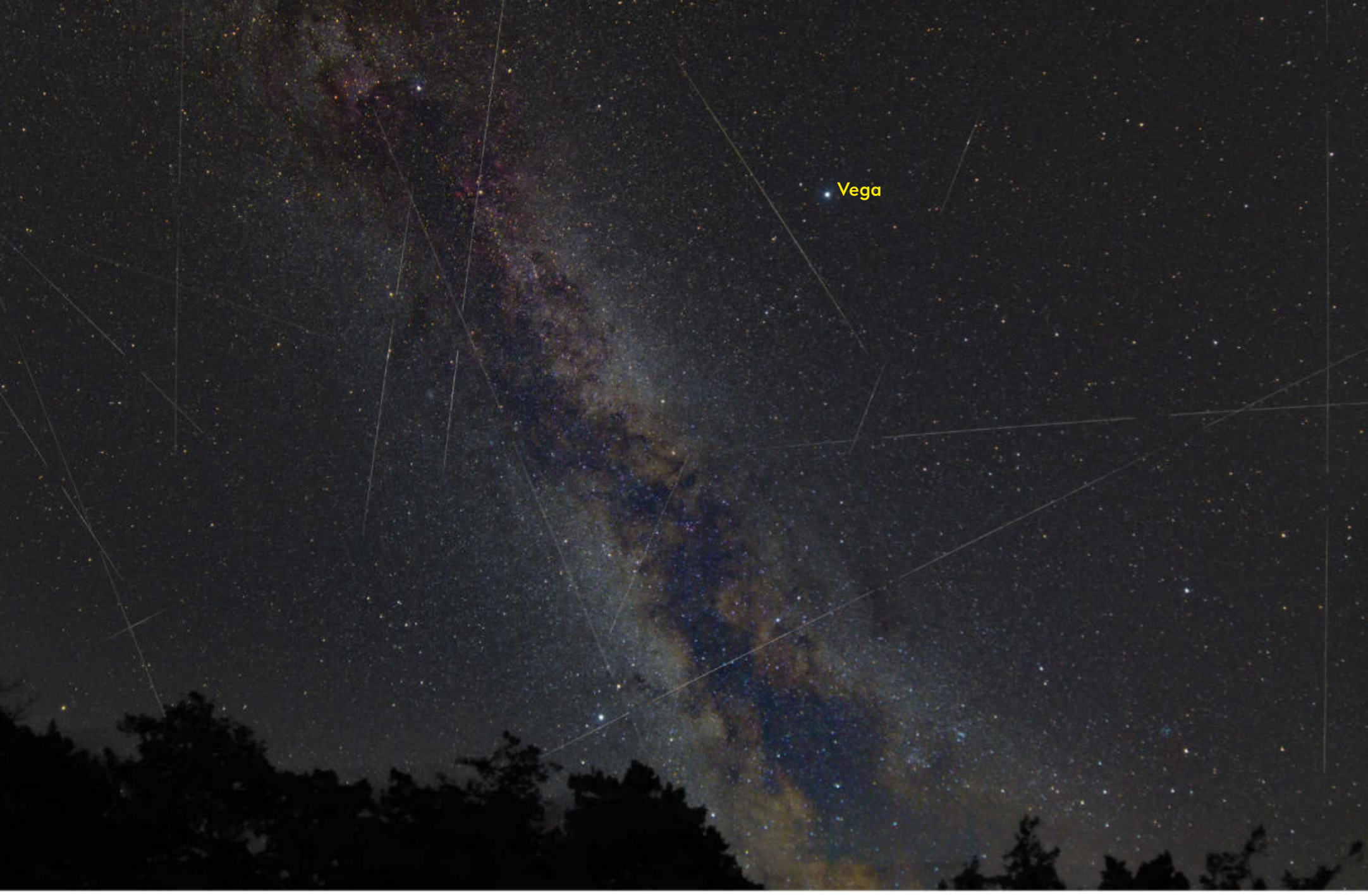
Equipment: ZWO ASI1600MM Pro camera, William Optics Zenithstar 73 apo refractor, iOptron GEM28 mount **Exposure:** L 180', R 60', G 60', B 60'" **Software:** PixInsight

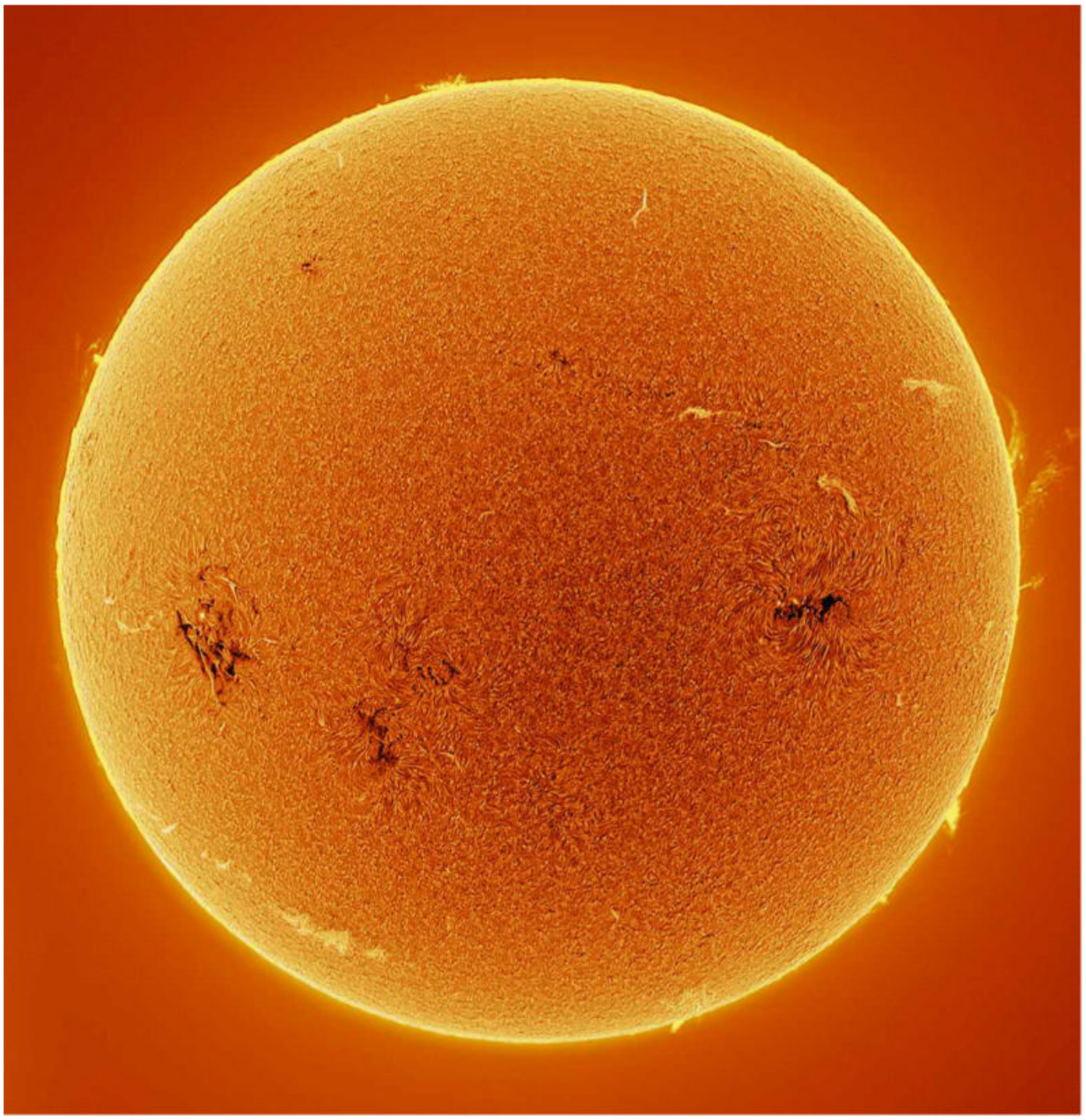
◁ The Andromeda Galaxy

Paul Gordon, Rochford, Essex, 1 and 3 October 2021

Paul says: "It was a clear night with stable seeing so I targeted Andromeda as it was close to the zenith and favourably placed."

Equipment: ZWO ASI533MC camera, William Optics Zenithstar 73 apo refractor, Sky-Watcher HEQ5 Pro mount **Exposure:** 51x 2', gain 300 **Software:** SharpCap, DeepSkyStacker, Topaz, Photoshop





△ Satellite sky

Adam Gray, New Forest, Hampshire, 13 August 2021

Adam says: "This highlights the problem with the number of satellites in our skies. I was imaging the Perseids, but the only meteor here is to the left of the star Vega."

Equipment: Canon 2000D DSLR, Samyang 14mm lens, Sky-Watcher Star Adventurer 2i **Exposure:** ISO 1600 f/2.8, 84x 30" **Software:** Photoshop

◁ Sunspots

Arturo Buenrostro, Dallas, Texas, USA, 30 October 2021

Arturo says: "Accelerating solar activity reveals new landscapes"

Equipment: ZWO ASI178MM camera, Lunt 60mm H-Alpha telescope with double-stack 50mm filter and B1200 blocking filter, Sky-Watcher AZ-EQ6 Pro mount **Exposure:** video of 3,500 frames (70") **Software:** FireCapture, AutoStakkert!, RegiStax, Photoshop

◁ The Little Rosette Nebula

Chad Leader, North Brentwood, Maryland, USA, 6, 7 and 9 September 2021

Chad says: "Although not an object that is photographed very often, Sh2-170 boasts some interesting details when imaged at a longer focal length."

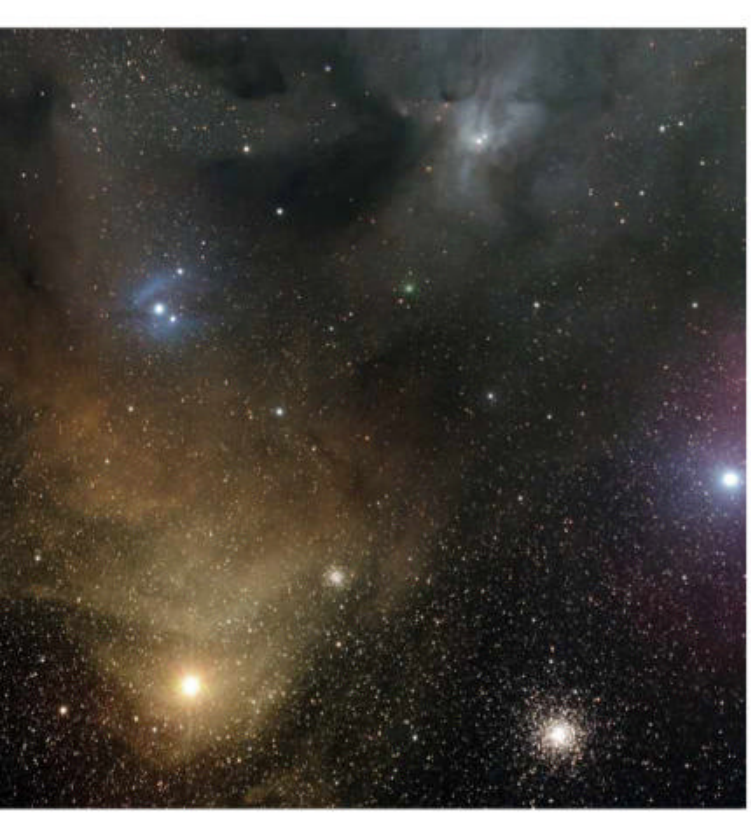
Equipment: ZWO ASI294MM Pro camera, Celestron 8-inch EdgeHD OTA, Sky-Watcher EQ6-R Pro mount **Exposure:** Ha 96x 300", OIII 94x 300", SII 83x 300" **Software:** PixInsight

▽ Comet passing Antares

José Chambó, remotely via Siding Spring Observatory, NSW Australia, 5 October 2021

José says: "Comet C/2020 T2 (Palomar) adds a note of discordant green as it moves between dark clouds of dust, reflection nebulae illuminated by the red supergiant star Antares, ancient globular clusters and clouds of ionised hydrogen. All this, perhaps, is one of the most dramatic landscapes in the Milky Way."

Equipment: FLI ProLine 16803 camera, TeleVue NP127 refractor, 10Micron 2000 HPS mount **Exposure:** 11' total **Software:** PixInsight



△ Supernova remnant CTB-1

Bill Batchelor, Coquitlam, British Columbia, Canada, July–August 2021

Bill says: "This large but very faint target is a challenge, especially through several nights of thick smoke from regional forest fires."

Equipment: ZWO ASI1600MM Pro camera, William Optics FLT98 refractor, Celestron Advanced AVX mount **Exposure:** Ha 13h, OIII 8h, SII 3h **Software:** SG Pro, PixInsight

UNISTELLAR

THE UNIVERSE AWAITS

M27
DUMBBELL

DIST. : 1,360 LY
MGN. : 7.5

M51
WHIRLPOOL

DIST. : 23.16 MILLION LY
MGN. : 8.4

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★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books on meteor showers and the astronomical phenomena we can't see, plus a roundup of the latest gear

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FIRST LIGHT

Sky-Watcher Skymax-127 Virtuoso GTi telescope

A highly portable and compact telescope that creates its own Wi-Fi network

WORDS: PAUL MONEY

VITAL STATS

- **Price** £549
- **Design** Maksutov-Cassegrain altaz Go-To Wi-Fi tabletop telescope
- **Optics** 127mm (5-inch) primary mirror
- **Focal length** 1,500mm, f/11.8
- **Mount** Wi-Fi, computerised, altaz and single-arm
- **Ports** Power connector, camera port, hand-controller port, integrated Wi-Fi adaptor, on-off switch
- **Tracking rates** Sidereal, lunar, and solar; alignment free
- **Extras** Red-dot finder, 25mm and 10mm 1.25-inch-fit eyepieces, spirit level
- **Weight** 10kg (total kit weight)
- **Supplier** Optical Vision Ltd
- **Tel** 01359 244200
- **www.** opticalvision.co.uk

Tabletop telescopes, such as the Sky-Watcher Skymax-127 Virtuoso GTi, have come to the fore because of their lightweight versatility. As a compact telescope combined with a single-arm, Wi-Fi-controllable Go-To mount it offers to make the night sky available at the touch of an on-screen button.

The Skymax-127's optical tube has a Maksutov-Cassegrain design that folds a 1,500mm-long light path into a tube that's just 370mm long (excluding the star diagonal). It has a 127mm-diameter primary mirror, and its long focal length (with a focal ratio of f/11.8) makes it ideal for lunar, planetary and double-star viewing, although you can also observe brighter deep-sky targets with it as well.

A red-dot finder allows for initial alignment and along with a star diagonal, there are 25mm and 10mm eyepieces, which give magnifications of 60x and 150x respectively. The single-arm mount houses the electronics and includes a battery compartment for eight AA-size batteries, as well as ports for an optional power supply and camera, and an integrated Wi-Fi adaptor. There's also a hand-controller port if you don't want to use your smartphone (the handset for this is sold separately).

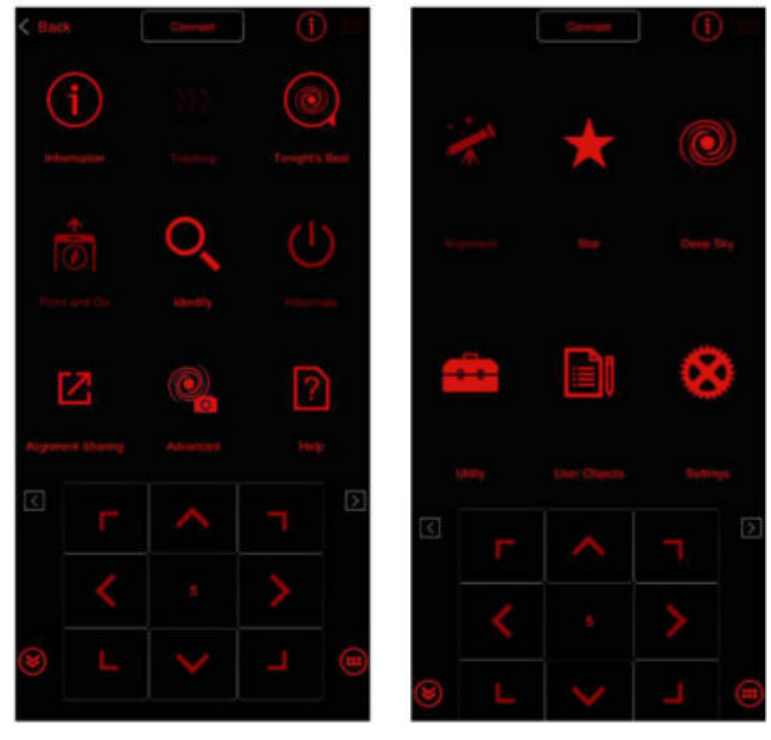
Versatile and portable

The telescope's base has a built-in spirit level and both axes can be locked and unlocked via clutches for free movement. When combined with Sky-Watcher's 'Freedom-Find' dual-encoder technology, this means you can do a star-alignment that will be retained after the clutches are unlocked. The telescope is attached via a Vixen-style bar and an adaptor, and it can be easily removed for travelling. The mount's underside has a ⅜-inch thread so you can attach it to a tripod if that's more convenient.

Being a tabletop-style mount you can use it manually, like a mini-Dobsonian mount, to enjoy the night sky without power. However, it's the integrated Wi-Fi adaptor that enables this scope to be controlled with a smartphone or tablet (either an Android or iOS system), and this allows you to use it anywhere. ▸

Flexible Wi-Fi control

The Virtuoso GTi single-arm tabletop mount houses a wireless network adaptor, so you can connect with a smartphone or tablet and control the mount. This control is achieved by using the SynScan Pro app that can be downloaded for both Android and iOS devices. Turn on the mount and it immediately broadcasts the wireless signal that you use to connect to your device. Open the SynScan app and select 'Connect', and it'll pick up the scope's signal and make the connection. You can then use the app to control the scope's functions, such as performing star alignment and locating targets from the built-in lists available (note that Solar System objects are located under the 'Stars' menu). The app worked well during this test and once connected, it also allows you to open planetarium apps, such as SkySafari, and to select 'SkyWatcher SynScanLink' in the telescope setup page to transfer control to even more targets.



▲ Simple controls and menus make operating the telescope with the SynScan Pro app a breeze

@THESHED/PHOTOSTUDIO X 4, PAUL MONEY X 2

Single-arm Go-To altaz mount

The single-arm mount is a table-top Dobsonian-style design with an integrated spirit level to help with setup, ports and a battery compartment. There's a Vixen-style saddle for attaching the telescope and a retaining knob to secure it in place. Both axes can be loosened for manual adjustment.

Focuser and finder

The red-dot finder is useful for initial alignment, but it can fall victim to dew quite quickly. Focusing is achieved via a knob at the eyepiece end of the tube that pushes against the main mirror, moving it smoothly back and forth.

Optics

This Maksutov telescope has a 127mm primary mirror and a front corrector lens that also holds the secondary mirror. It has a focal length of 1,500mm and a focal ratio of f/11.8 – ideal for planetary and lunar viewing, but also for brighter deep-sky targets.

Eyepieces and diagonal

Two 1.25-inch eyepieces are supplied: a 25mm giving 60x magnification and a 10mm giving 150x magnification. They both have rubber eyecups and delivered good views of the test targets. A star diagonal allows for a more comfortable viewing angle, especially for targets high in the sky.

FIRST LIGHT

KIT TO ADD

1. Sky-Watcher 1.75-inch diameter stainless steel tripod

2. Sky-Watcher 7Ah power tank

3. Sky-Watcher 1.25-inch lunar and planetary filter set

► It was easy to connect to the SynScan SSID to our iPhone XR (and iPad Pro) and, once the app has connected to the telescope, it lets you perform the star-alignment with either one, two or three stars, the brightest star, or north and level alignments. We found that two and three-star alignments gave the best tracking and Go-To results in this test.

In terms of the views, Saturn presented crisp detail through the 25mm eyepiece – the rings were well defined, there was a hint of a northern belt and a good view of Titan. The 10mm eyepiece revealed the Cassini Division in the rings, along with three more moons (Rhea, Tethys and Dione) and it gave a better view of the belt around the planet.

Sharp detail, even at distance

Jupiter was the next target and the views were gorgeous. The planet's northern belt was clearly a brownish colour and much wider than the slimmer and fainter southern belt. It was possible to make out hints of plume features with the 10mm eyepiece, as well as subtle hints of more belts. All four Galilean moons were visible too. Our Moon was the target for the next test, a week later, and it almost filled the view through the 25mm eyepiece, presenting lots of detail to enjoy. Switching to the 10mm allowed us to explore the lunar southern hemisphere in detail, taking in Clavius, Tycho, Maginus and other craters.

Next, we tested some of the better-known and brightest deep-sky targets: M81 appeared as a pale oval and M82 as a dappled sliver of light. Both just fit in the field of view of the 25mm eyepiece, as did the Pleiades, M45. Meanwhile, Albireo (Beta (β) Cygni) was resplendent with gold and pale-blue components, and with the 10mm eyepiece it was possible to split the 'double double' star in Lyra into all four parts.

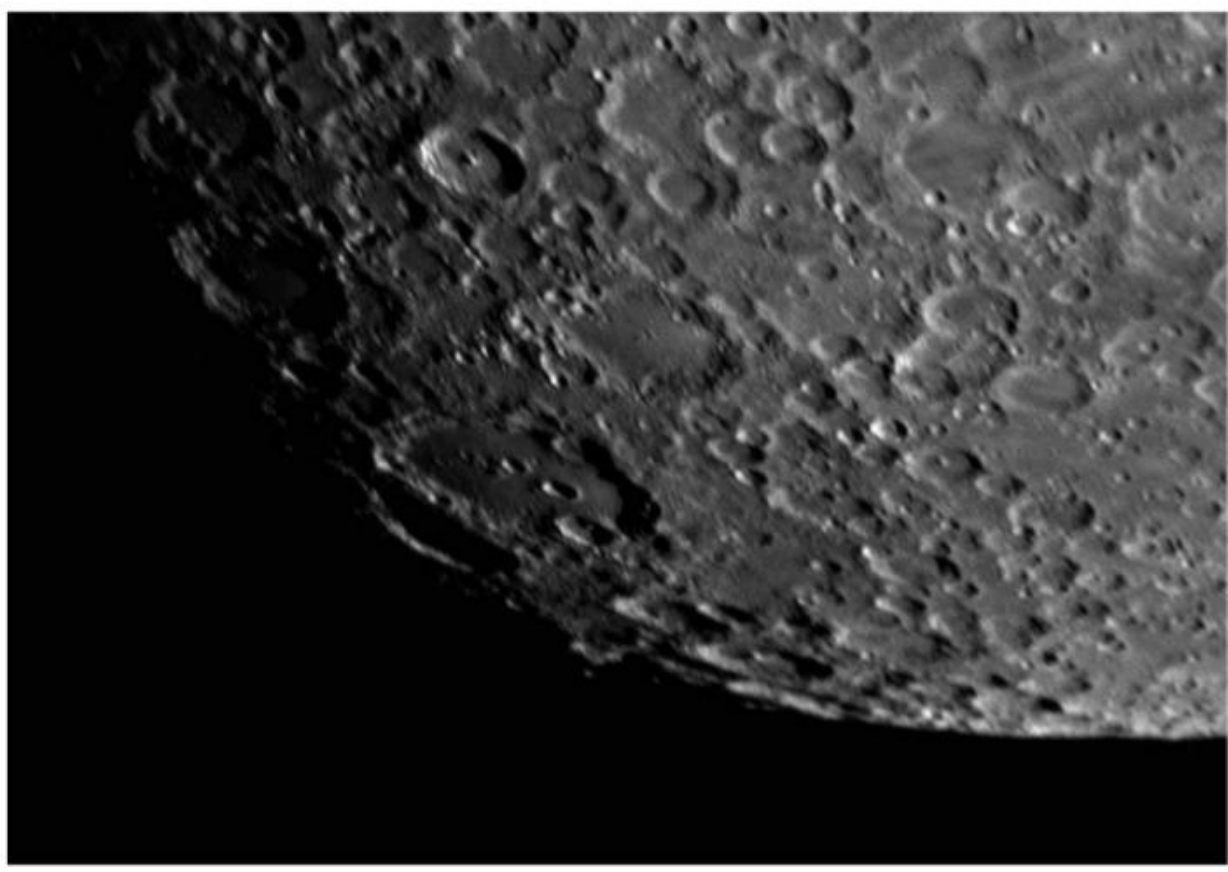
Overall, the Sky-Watcher Skymax-127 Virtuoso GTi was a delight to use on a wide range of targets, and can be highly recommended.

VERDICT

Assembly	★★★★½
Build & Design	★★★★½
Ease of use	★★★★½
Features	★★★★½
Optics	★★★★½
OVERALL	★★★★½

Ports and battery compartment

The arm of the mount houses a compartment for eight AA batteries (not supplied), the on-off switch, a power connector for an external 12V power pack, a snap camera port and a port for connecting an optional SynScan handset (although this shouldn't be needed due to the Wi-Fi control).



▲ A close-up of the Clavius and Tycho regions of the Moon, taken with the Skymax-127 and a ZWO ASI 224MC webcam, using a stack of 400 frames

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FIRST LIGHT

Altair Astro Hypercam AA24CFX full-frame colour camera

A superior deep-sky imaging camera that reveals distant galaxies in detail

WORDS: TIM JARDINE

VITAL STATS

- **Price** £2,799
- **Sensor** Sony IMX410 CMOS Colour
- **Resolution** 24MP, 6,064 x 4,040 pixels
- **Pixel size** 5.94 micrometres
- **Size** 100mm x 92mm diameter
- **Weight** 710g
- **Accessories** 1.5m USB lead, 12V PSU, hard carry case
- **www.altairastro.com**
- **Tel** 01263 731505

Altair Astro has recently introduced large format astro cameras to its comprehensive range, and this month we are putting one of these to the test – the Hypercam AA24CFX 14-bit colour camera. The AA24CFX's large sensor requires a telescope that can provide a suitable wide and flat imaging circle with good colour correction. We matched the camera to our 150mm triplet refractor, which gives a flat image circle of 44mm, and illuminates the sensor with minimal vignetting issues. Conveniently, the front thread on the camera is M54 x 0.75mm, which allows for an unobstructed light passage. Optional reducing flanges could reduce this down to M48, but we were able to take advantage of the larger fittings on our equipment. As a colour camera with an IR+UV (infrared and ultraviolet) filtered sensor window we found that no additional filters were necessary, and we were able to mount the AA24CFX directly onto our telescope. It's also possible to use modern multi-band filters with this camera, with consideration for maintaining an unobstructed light path.

Setting up the camera proved straightforward, even though our computer didn't quite meet the high-end specifications recommended (these are a Windows 10 Pro 64-bit operating system; an Intel processor i7; and 16GB RAM). Backup drivers are provided on a disc, but we downloaded the latest ones from the Altair Astro website, and when we plugged in the camera it was immediately recognised and ready to run with the AltairCapture software. It is worth noting that the AA24CFX requires a 12V DC power supply; a basic PSU (power supply unit) with a mains plug is provided in the package, but for convenience we were also able to run it using our observatory's 12V supply.

Keeping cool

Once running we turned on the thermoelectric cooling (TEC) system and let the camera stabilise for a few minutes, allowing it cool down to a sensible –10°C. Even with such a large chip, the USB 3.0 connection is a speedy interface, and we used live focusing with a steady frame rate to ensure good focus. Naturally, this large camera isn't designed for fast frame-rate applications like planetary imaging, but we were getting about 5fps in full frame, 14-bit mode, and up to 15fps with a smaller region of interest setting. These results demonstrate how well ▸

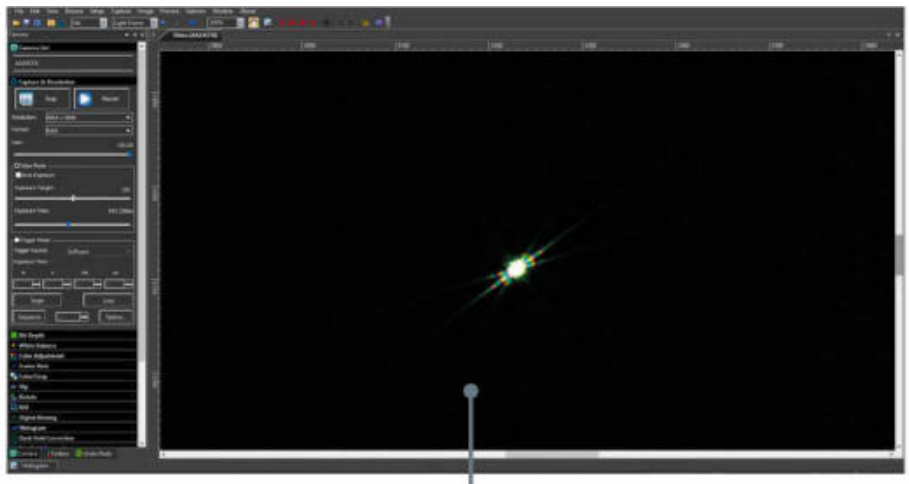
@THESHED_PHOTOSTUDIO X 4, TIM JARDINE

Sensitive CMOS sensor

The full-frame CMOS chip in the AA24CFX is 36mm x 24mm, offering a considerable 864mm² of image-capturing area. The sensor, an IMX410, is a back-illuminated unit made by Sony, and the pixels are arranged in a 6,064 x 4,040 array. This makes the individual pixels comparatively large, hence the sensitivity is enhanced while unwanted noise is reduced. The typical arcsecond/pixel ratios you get with telescopes (such as large refractors, SCTs and Newtonians) make this camera a sensible choice as a high-performance, one-shot colour option.

As a 14-bit camera, the AA24CFX has a range of over 16,000 levels of grey available, and this impressive dynamic range enables it to handle very bright features in deep-sky objects alongside very faint ones.

Indeed, when we stretched the images of bright young stars in M45 to reveal the much fainter reflection nebulosity and dust that surrounds this popular object, they were not blown out. In fact, the ability of this sensitive camera to dig out extremely faint, tiny galaxies from mediocre suburban skies is really impressive.



AltairCapture software

Although it's compatible with a host of imaging applications, Altair's own capture software allows easy and full control of all aspects of the camera, including the window heating and sensor cooling settings, offering you a quick choice between gain settings, bit depth, region of interest and image capture details.

Compact, balanced design

Despite the demands of design imposed by the large imaging sensor, the overall size and weight of the AA24CFX has been kept within sensible proportions. At 710g, the round barrel design sat comfortably on the telescope used for this test without making uncomfortably heavy demands on the mount or focuser.

USB 2.0 hub

A two-port USB hub on the back of the camera allows you to attach it to low-demand USB devices, such as a filter wheel, autofocuser and so on. The camera needs a good-quality USB 3.0 lead no more than 2m long to get the best performance.

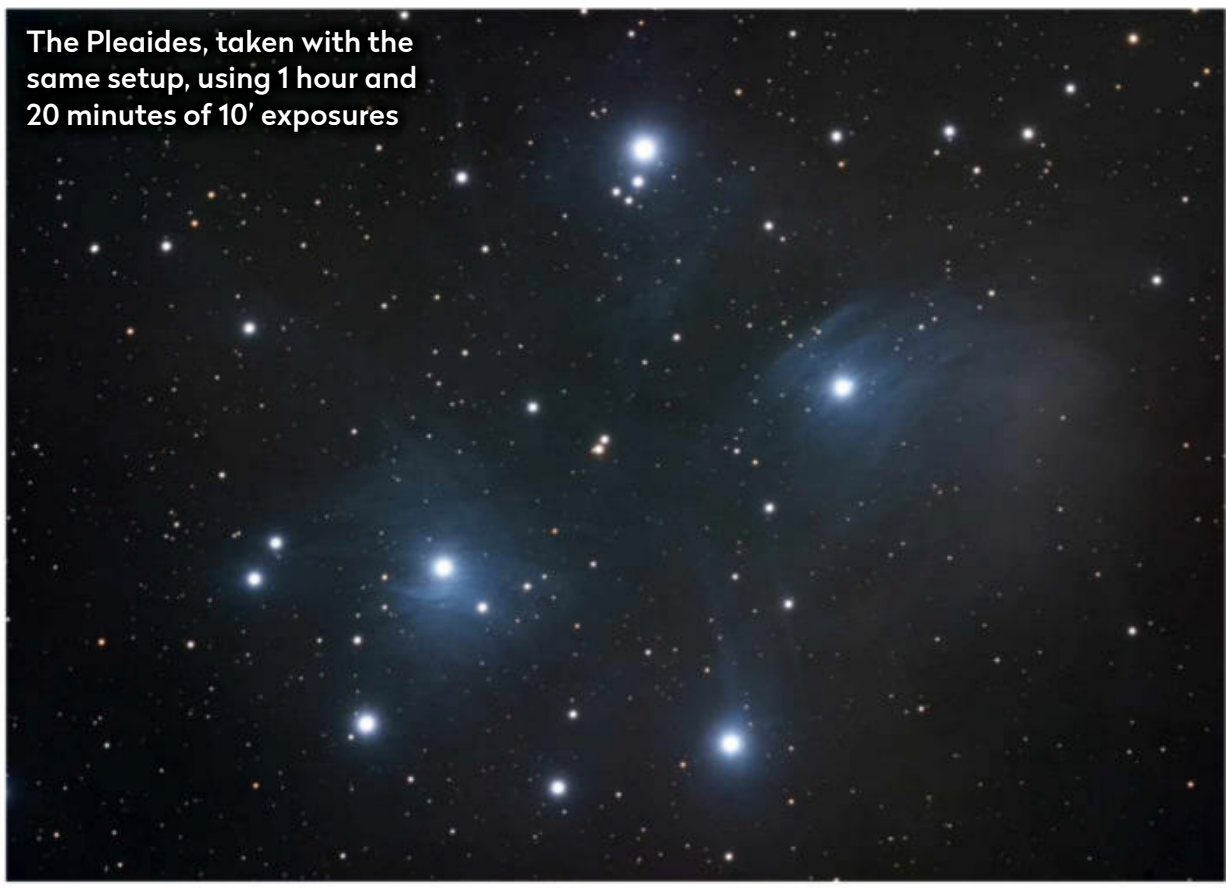
Thermoelectric cooling

Capable of reaching –35°C below ambient temperature, the large heat sink and quiet fan combine with a thermoelectric cooling (TEC) unit to hold stable temperatures when chilling the sensor. The optical window has an adjustable heater to avoid dewing up during imaging and is guaranteed to remain frost-free for two years.

Hard case

A moulded armoured plastic case with foam inserts is provided to protect the camera from damage while transporting or storing it. Inside are cut-outs that allow the camera – along with a 12V power supply unit, leads and USB 3.0 cable – to be stowed neatly in one place. Padlocks can be used to secure the case if necessary.

A cropped image of M31, taken with the AA24CFX camera and a Sky-Watcher Esprit 150ED refractor, using 3 hours of 10' and 15' exposures



The Pleaides, taken with the same setup, using 1 hour and 20 minutes of 10' exposures

▸ the 24MP sensor produces the smooth transfer of large amounts of data.

The AA24CFX is a CMOS camera that offers a range of gain settings. To ensure that we can get some usable images for a review we normally start off by using low gain, which gives us a predictable and useful point of reference. Next, if the skies allow it, we can go on to experiment with other settings. Low gain settings require longer exposures, and these can highlight issues with noise (unwanted artefacts), dodgy pixels or amp glow. In this regard, the results from the AA24CFX were simply exceptional.

We took a series of individual 15-minute exposures, and then stretched them to see the results. There was no visible amp glow whatsoever, and the overall lack of noise and hot or cold pixels produced excellent images. These proved to be very acceptable, even without additional calibration using dark frames.

Unveiling colours

Once stacked, we found that a series of 10- and 15-minute exposures we had taken of the Andromeda Galaxy, M31, revealed fantastic details within the arms of the galaxy. Hints of star-forming regions showed up as reddish purple, while star clusters and groupings were picked out in remarkable detail. The colours at the galaxy's centre, which is extremely bright, were well controlled, and this allowed the natural colours of the dust lanes to shine through.

The impressive results continued when we tested the AA24CFX on a range of larger objects; it hoovered up the details in deep-sky objects like the Pleiades, M45, the Double Cluster (NGC 869 and NGC 884) and the Pinwheel Galaxy, M101. Remarkably, a 10-minute test image of spiral galaxy NGC 891, taken in suburban skies, revealed a multitude of tiny background galaxies – dozens of them, with over a hundred in one frame.

To sum up, our results – even from our limited and basic tests – demonstrated that the AA24CFX is an extremely capable, large format, low-noise camera, which is capable of producing stunning images.

KIT TO ADD

1. Hypercam full-frame M54 to M48 adjustable-tilt adaptor

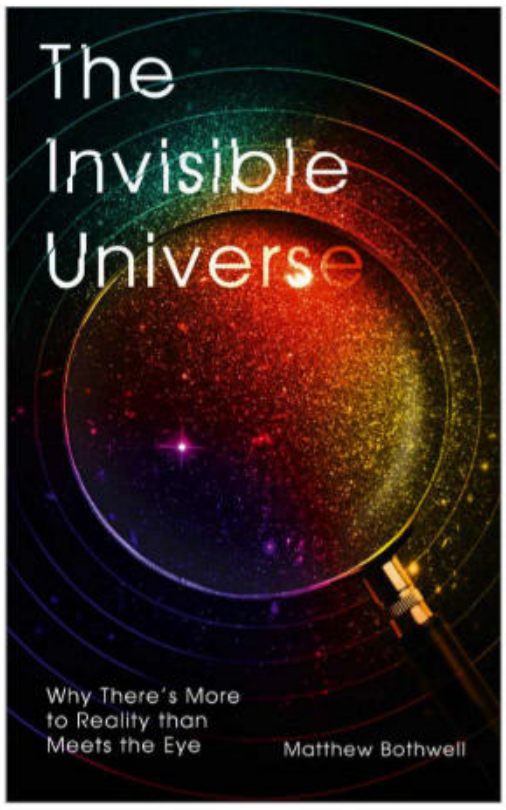
2. Altair 115EDT-X triplet APO refractor

3. Altair dual-band 7nm light-pollution filter, 2-inch

VERDICT

Build and design	★★★★★
Connectivity	★★★★½
Ease of use	★★★★☆
Features	★★★★½
Imaging quality	★★★★★
OVERALL	★★★★½

BOOKS



The Invisible Universe

Matthew Bothwell
Oneworld
£18.99 ● HB

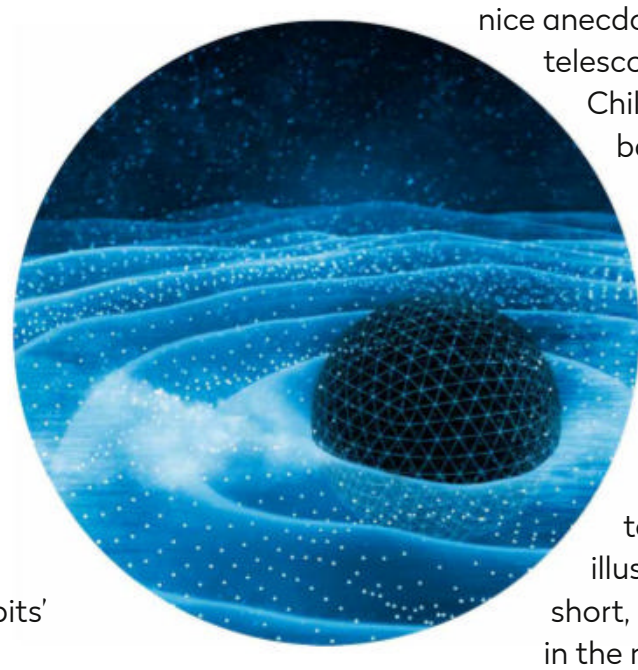
Astronomy is often thought of as a very visual field, with lots of focus on what we can see. In *The Invisible Universe*, Matthew Bothwell explores those bits that we can't see – although that's a little bit of a disservice as those 'bits' amount to the vast majority of the cosmos.

To understand what we can't see, it's worth first of all understanding why we see what we can actually see. The first chapter is a brief physics lesson covering the history of the discovery and theoretical understanding of light's true nature, including a bit of quantum physics.

Most of the chapters focus on a particular part of the spectrum or a particular discovery. In every case there's a narrative taking the reader through a potted history, including some very recent discoveries. It doesn't try to walk linearly along the spectrum or through a history of discoveries, as the journey of humanity's discovery hasn't worked like that. No book like this could avoid jumping around in history, but overall there's a logical flow.

It's rather focused on the long-wavelength end of the spectrum, perhaps due to the author's background, and if you have a passion for learning about X-rays or gamma rays, then this isn't the book for you. But in terms of radio, infrared and microwaves it's very comprehensive, and when you consider the chapters on black holes, dark matter gravitational waves and the end of the Universe, it certainly covers a lot of ground.

Throughout the book, concepts are well explained, using metaphors and analogies to create an accessible writing style. The author's day job as an observational astronomer comes through, and there are nice anecdotes about trips to telescopes in Hawaii and Chile, and a few from his base at the University of Cambridge, an institution steeped in astronomical history.



Although we can't see gravitational waves, we know they are there

ANDREUSK/ISTOCK/GETTY IMAGES

There are around a dozen black and white images embedded in the text by way of illustration, as well as a short, glossy photo section in the middle, though it is a little frustrating to have to flip back and forth where these are particularly relevant to the story.

An engaging read overall, this book will be of interest to anyone wanting to know more about how we've learned what we know about the Universe. ★★★★☆

***Chris North** is Ogden Science Lecturer and STFC Public Engagement Fellow at Cardiff University*

Interview with the author
Matthew Bothwell

How can we observe the 'invisible' Universe?

Lots of things in the Universe, from young stars to dead stars, black holes to entire galaxies, don't emit much visible light. To see them, we have to use other parts of the electromagnetic spectrum such as radio waves, infrared and X-rays. Some things don't emit light at all, like dark matter or gravitational waves. All things considered, the Universe we can see really is just the tip of the iceberg.

How can we solve the mystery of dark matter?

We can go big, looking at the Universe as a whole and working backwards by asking, what kind of dark matter would produce a Universe that looks like this? The answer we get is that dark matter is a heavy, slow-moving kind of particle that doesn't emit light. Or we can go small and build detectors to hunt for dark matter particles right here on Earth. These tend to be deep underground, shielded from cosmic radiation. So far, these experiments haven't found anything, so we keep hunting.

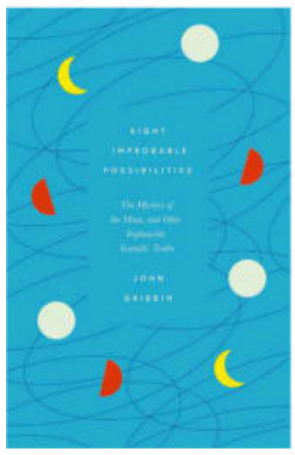
What is the Universe's ultimate fate?

I'd love to know! We don't really understand dark energy, the strange force that seems to be pushing the Universe apart faster and faster. If it's some kind of constant built into the fabric of space-time, then the Universe is destined to get bigger and bigger, and colder and emptier, forever. If it changes with time, then all bets are off: the Universe could ultimately end up tearing itself to pieces or even collapsing back down to nothingness.

***Matthew Bothwell** is Public Astronomer at the University of Cambridge's Institute of Astronomy*

Eight Improbable Possibilities

John Gribbin
Icon Books
£10.99 ● HB



The title of John Gribbin's latest book nods towards the famous dictum of Sherlock Holmes: "When you have eliminated the impossible, whatever remains, however improbable, must be the truth." This, Gribbin argues in his introduction, is a fairly good encapsulation of the scientific method: testing hypotheses and drawing closer to the truth (though in science never quite being certain we have reached it) every time a failure forces us to look again at our assumptions about the Universe.

The eight short essays that make up this volume explore some of the unexpected and highly improbable conclusions that modern science has reached using this method. Gribbin casts a wide net and displays his breadth of knowledge in packing a lot into each chapter, while ensuring the prose remains readable.

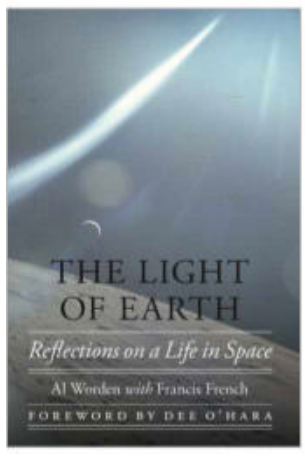
Topics range from the existence of gravitational waves that ripple across the Universe from the Big Bang, to the descent of all life on Earth from a single cell; and from a mind-bending exploration of the true concept of relativity, to the link between ice ages and human evolution.

Perhaps the most intriguing chapter is one that provides the book with its subtitle, *The Mystery of the Moon, and Other Implausible Scientific Truths*, where Gribbin looks at the origins of the Moon and raises some connections between the presence of our satellite and Earth's own habitability which I've never seen pointed out before. A brief read, but one that may inspire readers to dig deeper. ★★★★☆

***Giles Sparrow** is a science writer and a fellow of the Royal Astronomical Society*

The Light of Earth

Al Worden with Francis French
University of Nebraska Press
£21.99 ● HB



Ever wondered what Al Worden really thought of Neil Armstrong and Buzz Aldrin? In his latest book written before his death in 2020, the Apollo 15 astronaut shares his candid opinions and does not hold back.

Worden's raw and honest musings on the space programme, flying to the Moon, about those involved in the Apollo missions, and his life as a retired astronaut are very refreshing to read, and at points quite eye-opening.

There are some funny moments, such as Worden's experiences with fans at conventions, but there are also heartbreaking points when he recounts the times he learnt of the deaths of fellow astronauts, and the pain of those moments can be felt though his words.

However, there isn't much structure to this collection of thoughts, which can jump from one topic to the next, like when Worden goes from sharing his opinions on the International Space Station to musing about being inside a Soyuz capsule. Then there is the infamous postal scandal that cost Worden his job as an astronaut: it is alluded to but never explained in detail, which can be quite frustrating to a reader who doesn't know the story.

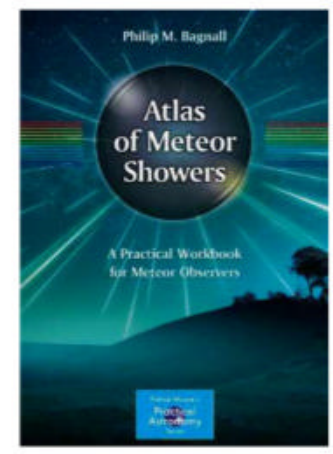
This book is not so much Worden's reflections on a life in space, but more a collection of seemingly random thoughts and opinions put together in its most honest and uncensored form. Is this book a good way to learn about the late Al Worden? I would say not. But it could be a good place to start. ★★★★☆

***Melissa Brobby** is a science communicator and Social Media Officer at the Institute of Physics*

Atlas of Meteor Showers

Philip M Bagnall
Springer
£27.99 ● PB

PACKED WITH PRACTICAL TIPS



Meteors and meteorites can be the Hollywood blockbusters of astronomical objects. Thankfully, most are less impactful than the 2013 fireball above Chelyabinsk in Russia, which injured hundreds of people and was visible up to 100km away, but there is a perennial fascination in seeing them zip across the night sky.

If you are interested in more than just catching glimpses of these phenomena, this thorough and clearly written handbook (by the author of *The Star Atlas Companion*) will take you through the practicalities of observing the 10 major annual meteor showers. Because meteors appear in different parts of the sky and are very short-lived, telescopes tend not to be very useful for this sort of astronomy and *The Atlas of Meteor Showers* concentrates on naked-eye observations.

The book introduces the relevant science of meteor showers, explaining how meteors are caused by the debris of material shed from comets and asteroids, their surfaces heated up as they approach the Sun. When the resulting dust collides with Earth's atmosphere it can produce spectacular displays, as well as occasional meteorites that survive to land on the surface of our planet.

With huge amounts of detail on each of the major showers, the book seems clearly aimed at the interested and knowledgeable amateur who can navigate their way around a star chart and knows how magnitudes are defined. On the other hand, perhaps puzzlingly, it also has very basic advice about wrapping up warm when observing at night. But all in all, this is a welcome guide for those keen to spot these beautiful evanescent objects and learn more about them. ★★★★☆

***Pippa Goldschmidt** is an astronomy and science writer*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Orion 7.2 to 21.6mm zoom eyepiece

Price £110.99 • **Supplier** Orion
https://uk.telescope.com

It's not always possible to cart around dozens of eyepieces, making a zoom eyepiece a useful addition to your collection. Orion's gives you focal lengths from 7.2mm to 21.6mm with no change of ocular.

2 Heated fingerless mittens

Price £30.24 • **Supplier** The Heat Company
www.theheatcompany.com

These gloves allow you to balance keeping your fingers warm and maintaining dexterity. They turn into mittens and come with a pouch for a handwarmer.

3 Wonders of the Solar System cross stitch pattern

Price £18 • **Supplier** ClimbingGoatDesigns on Etsy
www.climbinggoat.co.uk

Sew the Solar System with this cross stitch pattern, designed to show the real planets as accurately as possible. This digital download comes with printable patterns and a guide to the thread colours.

4 Deep Sky Dad W0 Redcat 51 Flap Panel

Price £265 • **Supplier** First Light Optics
www.firstlightoptics.com

ADVANCED Taking flats can be cumbersome, but this device lets you automate the process. The panel attaches to the front of your telescope tube, then uses a motor to flip the panel out of the way when you want to image.

5 Altair Maxfield Newtonian 2-inch coma corrector

Price £190 • **Supplier** Harrison Telescopes •
www.harrisontelescopes.co.uk

Coma is an issue with Newtonians, where light around stars doesn't fully focus. Designed for 2-inch focuser barrels, this corrector has 95 per cent illumination up to 43mm in diameter, which suits full frame sensors.

6 NASA remote control Perseverance Mars rover

Price £39.99 • **Supplier** I Want One Of Those •
www.iwantoneofthose.com

Run a Mars mission in the garden or living room with this remote control model of Perseverance. It comes with a smartphone bracket, allowing you to create a rover's-eye-view recording of your explorations.

Ezzy Pearson interviews Ziteng Wang

Q&A WITH A RADIO ASTRONOMER

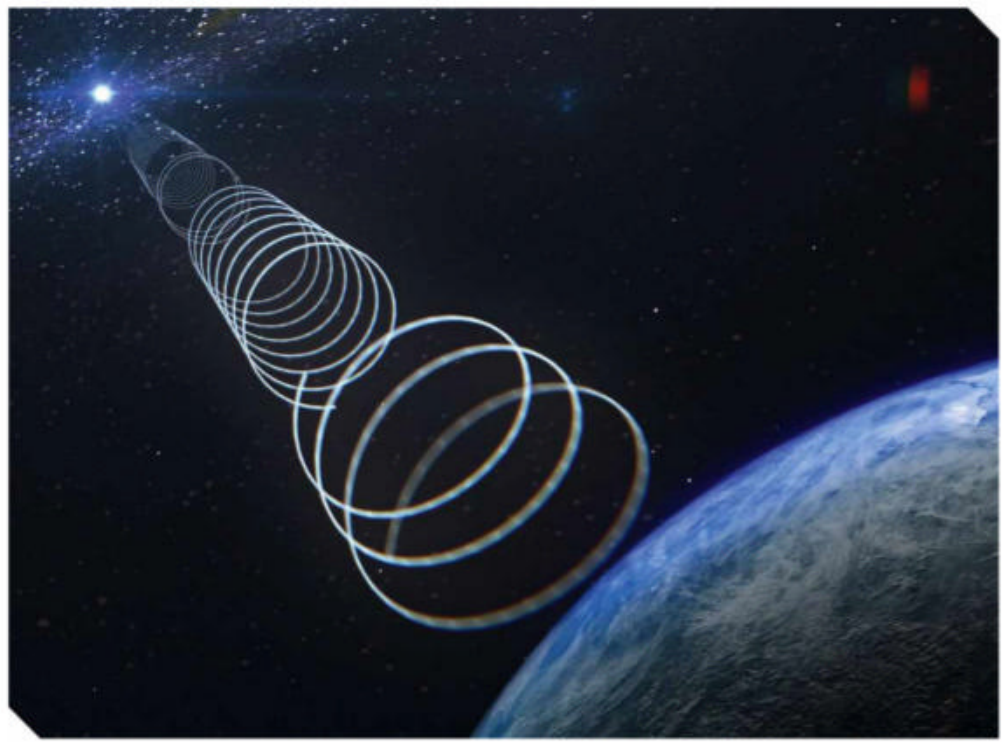
Strange radio signals beaming out from the centre of the Milky Way are unlike anything that astronomers have detected before

How did you first uncover the signal?
We discovered this source in early 2020, by using the Australian Square Kilometre Array Pathfinder (ASKAP) telescope, located in Western Australia. Our survey – Variables and Slow Transits (VAST) – is designed to discover radio sources that turn on and off or vary in brightness. We performed a search towards the Galactic centre and this signal was one of the most variable sources in the search.

What makes it so unusual?
The strangest aspect of this source is that it is highly polarised. Our eyes cannot distinguish between circularly polarised light and unpolarised, but ASKAP has the equivalent of polaroid sunglasses to filter it out. These kinds of sources are rare, usually in one observation, out of thousands of sources we only found 10 that were polarised. Adding to the mystery, the source of the radio signals turns on and off irregularly. While the brightness of this source can change dramatically, declining in a single day, the change can sometimes last for a few weeks.

Is the signal like anything we've found before?
No – we came up with several interpretations, but none of them can really fit well. We considered stars, as both stars and this source are detected in radio waves as signals that switch on and off – and both issue polarised signals. However, this new source is different to stars because we can't see anything in infrared wavelengths, and another key difference is that the radio signal is far too bright to be a star.

We also thought this source could be a pulsar (a dead star) or a flaring star, based on what we saw in the VAST data. Pulsars are rotating compact stars left over from stellar explosions. Although both pulsars and this source are polarised and have varying brightnesses, we have yet to see any evidence of short-timescale radio pulsation, like you'd expect from a pulsar, in any observations of this source. Another option is a magnetar, which is a pulsar with an extreme magnetic field. When these can be detected in radio observations, they can be detected in X-rays as well, but we have seen nothing in our X-ray observations for this new source.



▲ The mysterious radio signal, ASKAP J173608.2-321635, was picked up six times between January and September 2020, but what has been causing it?

SEBASTIAN ZENTILOMO

Ziteng Wang is a PhD Student at the School of Physics at the University of Sydney

What follow-up observations did you do?
We used the Parkes radio telescope to find short timescale pulsation, to investigate if it was a pulsar. We also used the MeerKAT telescope to look at the behaviour of the signal. We searched for the source in X-rays (with the Neil Gehrels Swift and Chandra X-ray Observatories) and infrared (with the Gemini telescope), but we saw nothing.

What could be causing the signal?
This signal shared some similarities with Galactic Centre Radio Transients (GCRTs) – variable radio sources detected near the Galactic centre, the origins of which are still a mystery. They turn on and off irregularly, are highly polarised, and there is nothing in X-ray or optical wavelengths. As the source is close to the Galactic centre, it could be a GCRT. However, the timescale of the burst from our source is not consistent with that for GCRTs. But we don't even know if all GCRTs share a common origin, so it is hard to say.

How will you investigate the signal further?
We will do further radio follow-up observations of this source, and perhaps joint observations in other wavelengths. We would like to observe the source for a longer time when it is radio bright. As it has not been seen in any other wavelengths, more detailed radio observation will help us locate the object in the visual spectrum. But we don't know when the source will turn bright again. It is troublesome.

What is it about SKA that makes it particularly helpful for investigating the signal?
SKA will be the most powerful radio telescope in the future. More detections for this signal can allow us to understand the behaviour of the signal, like when it will be on and when it will be off. It can help us find similar signals and pin down an interpretation.

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Begin the New Year with an occultation of Mars by the Moon, and discover Auriga's deep-sky treasures

When to use this chart

1 Jan at 00:00 AEDT (13:00 UT)
15 Jan at 23:00 AEDT (12:00 UT)
30 Jan at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JANUARY HIGHLIGHTS

From southeast mainland Australia there will be an occultation of Mars by the Moon, visible at dawn on 1 January. From Canberra and Melbourne you will see the disappearance around 30 minutes before sunrise, but from Sydney it will be a near miss (4 arcminutes from the limb). Adelaide will get the best view, from where you'll be able to see the disappearance and reappearance at 70 and 40 minutes before sunrise respectively. Low to the east, the lunar crescent will be quite thin.

STARS AND CONSTELLATIONS

Summer northern evening skies are dominated by Orion. Worthy of note is how many other constellations have common mythologies with the Hunter. The most obvious are his hunting dogs, Canis Major and Canis Minor. One lesser-known association is Lepus, the Hare, which lies at Orion's feet, directly above the star Rigel (Beta (β) Orionis). Though faint, Lepus's six main 3rd to 4th magnitude stars make an obvious asterism, which is visible under dark skies.

THE PLANETS

The presence of Mercury, Saturn and Jupiter in the western sky comes to an end in January, as they become twilight-only objects. Mercury is the first to depart, being in conjunction with the Sun mid-month, with Saturn following suit at January's close. Jupiter leaves near the end of twilight, with Neptune around an hour later. Meanwhile, Uranus is an evening object and sets around midnight. Mornings find Mars rising before dawn, with Venus and Mercury rising out of the solar glare.

DEEP-SKY OBJECTS

This month we visit the constellation of Auriga, the Charioteer. From Beta (β) Tauri move 3.2° northeast to find the double star 26 Aurigae (RA 5h 38.6m, dec. +30° 29'), which has a yellow mag. +5.5 primary and a mag. +8.4 blue/white companion, just 12 arcseconds apart.

Continue in the same direction a further 3.5° to discover the 5th magnitude open star cluster NGC 2099, or M37 (RA 5h 52.3m, dec. +32° 33'). Consisting of around 200 stars, ranging from 9th to 13th magnitude, it is quite compact and fits in a 14-arcminute circle. There is a central red star, while M37's brightest members are arranged in curves and triangles, merging into a busy star field.

Being near the galactic equator, this is an open cluster-rich area, with four others less than 6° away towards the northwest, including M36 and M38.

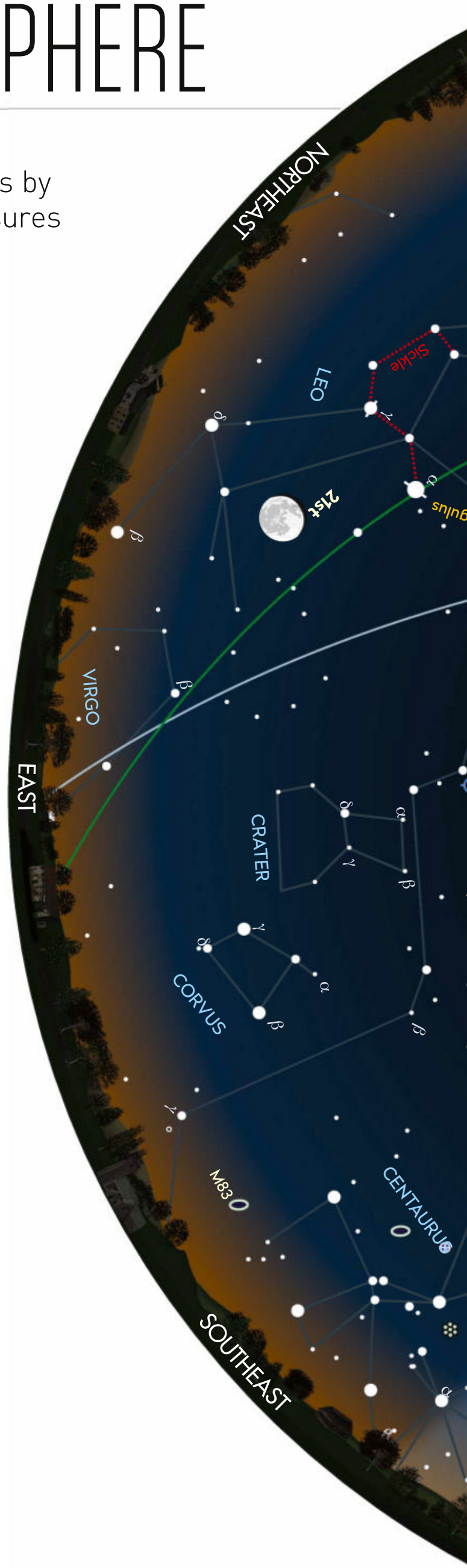
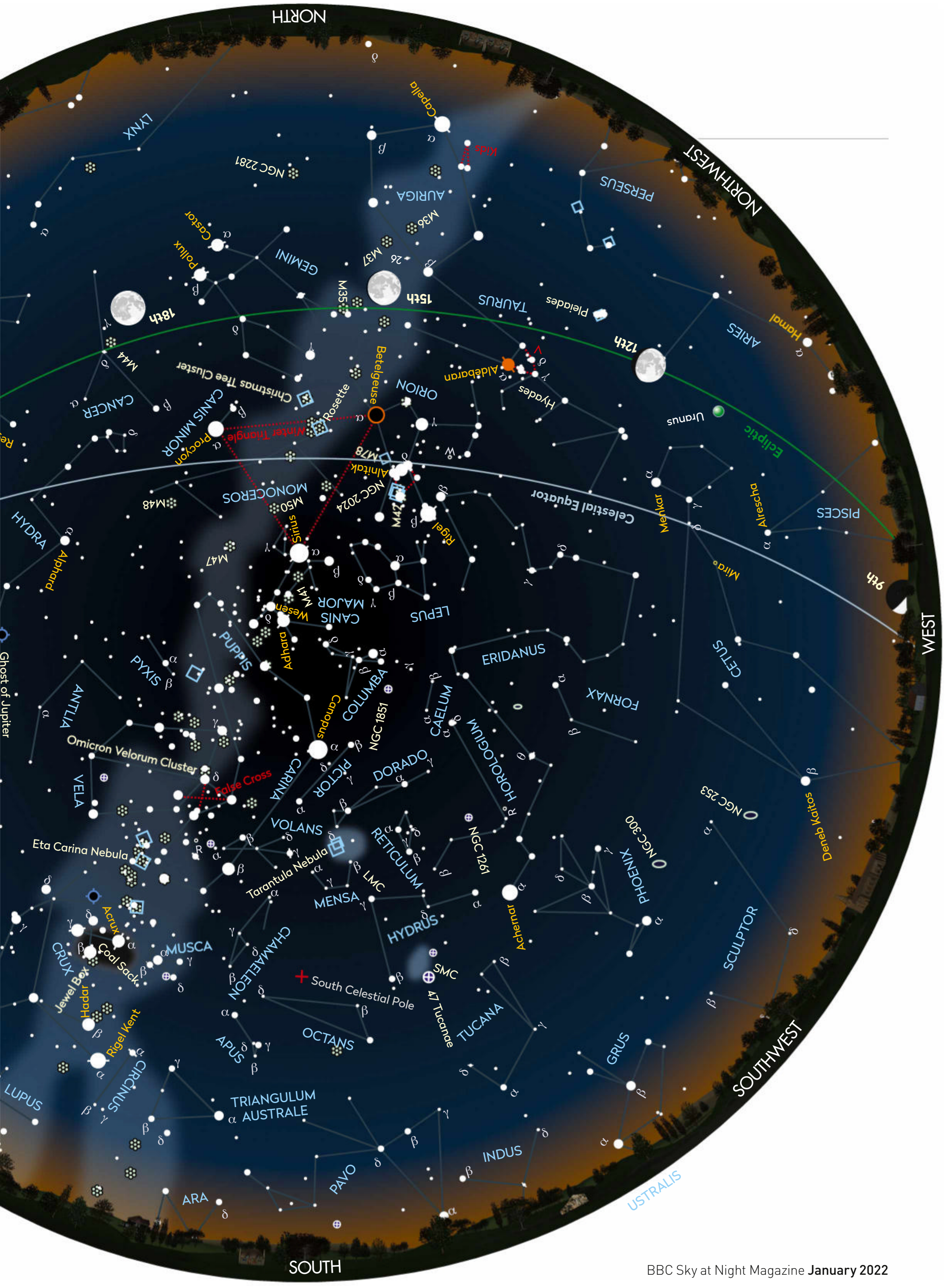


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Capella
Kids
LYNX
NGC 2281
AURIGA
M36
M37
26
Castor
Pollux
GEMINI
M35
15th
PERSEUS
Pleiades
TAURUS
12th
Hamal
ARIES
18th
M44
Betelgeuse
Aldebaran
Hyades
ORION
Christmas Tree Cluster
Rosette
CANCER
CANIS MINOR
Procyon
Winter Triangle
Uranus
Ecliptic
M78
Alnitak
NGC 2024
M42
MONOCEROS
M50
M48
Celestial Equator
Mehkar
Alrescha
PISCES
Rigel
Sirius
HYDRA
Alphard
M47
Mira
9th
LEPUS
CANIS MAJOR
M41
Wesen
Adhara
PUPPIS
PYXIS
ANTLIA
Canopus
COLUMBA
NGC 1851
CAELUM
HOROLOGIUM
ERIDANUS
FORNAX
CETUS
Omicron Velorum Cluster
False Cross
VELA
CARINA
PICTOR
DORADO
NGC 253
Denebb Kaitos
Eta Carina Nebula
VOLANS
Tarantula Nebula
RETICULUM
LMC
NGC 1261
MENSA
PHOENIX
NGC 300
Achernar
Acrux
Coal Sack
MUSCA
CRUX
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Hadar
Rigel Kent
CHAMAELEON
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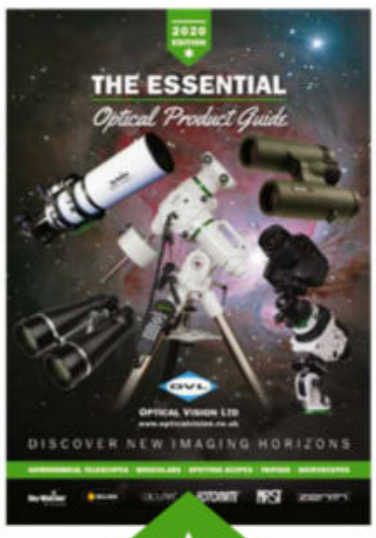

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